FOREST FIRES IN MICHIGAN

J. A. MITCHELL,
Lake States Forest Experiment Station

H. R. SAYRE,
Michigan Department of Conservation

MICHIGAN DEPARTMENT OF CONSERVATION
In cooperation with
UNITED STATES DEPARTMENT OF AGRICULTURE
Forest Service
1931

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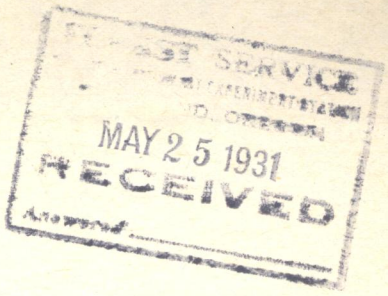
UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE



Lake States Forest Experiment Station
University Farm, St. Paul, Minnesota

RS
Publications
"Forest Fires in
Michigan"

May 22, 1931

Dear Sir:

The enclosed bulletin, "Forest Fires in Michigan", by J. A. Mitchell and H. R. Sayre, is the second of a series of reports by the Lake States Forest Experiment Station in cooperation with the State Conservation Departments. A similar report for Minnesota appeared in 1928.

It has been the purpose in these reports to collect and analyze all of the forest fire statistics which have been collected in recent years and point out the obvious conclusions which can be drawn from them.

In the past century, over 73 billion board feet of timber have been burned in forest fires in Michigan. This would be enough timber to run existing sawmills for over 100 years. Even today Michigan experiences many severe fire seasons. The average number of fires in a normal year is about 2500 and the average acreage burned over from 1923 to 1927 was close to 350,000. But gradually the effect of improved organization and awakened public interest is showing its effect and the size of the average fire is being consistently whittled down.

I feel sure that you will be interested in the detailed history of recent fire seasons and the careful analysis of the factors which go to make up the present fire problem.

Very truly yours,

Raphael Zon
Director

Enclosure

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INTRODUCTION

Michigan's Forest Fire Record.

In few states have forest fires been more numerous or caused more destruction than in Michigan. From time immemorial, but more especially since the beginning of active settlement, about 1825, forest fires have occurred annually. The result has been the destruction of billions* of feet of standing timber, an incalculable loss of other property, and close to 10,000,000 acres of forest land rendered unproductive.

Historical records contain frequent reference to the occurrence and destructiveness of forest fires, but no complete or accurate figures are available prior to the last decade. In fact only since 1922 are the fire statistics for the State even reasonably satisfactory.

The earliest of Michigan's several historic forest fires occurred in 1871, in which year it is reported that more than 2,000,000 acres burned over. From 1880 a fragmentary record extends to 1910 from which date increasingly complete and reliable figures are available. The record to date is summarized in Table 1.

Why Protect Forest Land from Fire?

If the damage resulting from forest fires was confined to the destruction of merchantable timber, equipment, and improvements alone, the losses would be great enough to justify protection. Such losses, however, account for but a fraction of the damage done. Far greater is the potential value of the young growth destroyed, the loss in yield due to soil depletion and understocking, the indirect losses resulting from the destruction of the forest cover, and the depressing economic effect of vast areas of idle land.

Commercial logging has frequently been blamed for the present deplorable condition of Michigan's cut-over lands. While a contributing factor, the chief cause has been fire, for, in the Lake States, a forest cover will establish itself after logging, regardless of the method of cutting employed, if only fires are prevented. It has been said, and it is in all probability true, that if fires had been prevented following logging, there would be, on the cut-over lands of the State today, second-growth timber worth more than the virgin stands that preceded it. What this would mean to northern Michigan in the way of tax revenue and local business is obvious. The public at large and the wood-using industries of the state would also benefit from an adequate local supply of forest products.

A generation ago Michigan was the leading lumber producing state in the country. Today it is fifteenth. In the meantime the demand for lumber and other forest products has increased. As a result Michigan is now, and has been for nearly twenty years, a timber importing state. Today, consumption exceeds production by nearly a billion board feet annually, approximately three-fourths of the timber used coming from outside the state.

*W. N. Sparhawk, in "The Economic Aspects of Forest Destruction in Northern Michigan", U. S. Department of Agriculture Technical Bulletin No. 92, states that, "Of Michigan's original stand of 380 billion board feet of saw timber, approximately 35 billion feet was cut and burned in clearing land; 73 billion feet was burned and wasted during or after lumbering or destroyed by forest fires independent of lumbering operations; 204 billion feet was cut for lumber; and 40 billion feet was cut for other products, such as railroad ties, shingles, staves, ship timbers, poles, pulpwood, veneer logs, furniture and vehicle dimension stock, and the like. In many parts of the State the amount of timber destroyed by fire exceeded the amount cut. In the region tributary to the Au Sable River, for instance, it has been estimated that 20 billion feet of pine was burned, and only 14 billion feet was cut by loggers.

TABLE 1.—FOREST FIRES—MICHIGAN 1871-1930.

Year.	No. of Forest Fires Reported.	Area Burned (Acres).	Loss Reported (Dollars).	Source of Data.
1871	.....	2,000,000	.....	Fragmentary record (1)
1880	267	238,270	$985,980	10th Census report
1881	.....	1,000,000	2,300,000	Fragmentary record (2)
1894	.....	.....	.....	Fragmentary record (3)
1896	.....	228,000	1,250,000	Fragmentary record
1908	.....	2,369,070	2,570,450	Fragmentary record (4)
1911	191	156,480	3,465,860	State report (5)
1912	139	40,170	66,100	State report
1913	.....	.....	.....	(No record)
1914	935	408,760	97,700	State report
1915	632	157,620	155,110	State report
1916	497	283,300	33,100	State report
1917	479	193,930	102,370	State report
1918	704	238,120	114,180	State report
1919	862	418,360	406,860	State report
1920	560	76,440	405,990	State report
1921	1,028	283,640	296,390	State report (6)
1922	538	38,480	35,260	State report
1923	1,336	466,470	534,810	State report
1924	1,936	242,960	149,770	State report
1925	3,887	733,750	475,120	State report
1926	1,524	145,060	101,730	State report
1927	2,394	94,720	71,050	State report
1928	1,340	67,147	59,966	State report
1929	2,457	145,060	54,230	State report
1930	4,690	290,304	279,162	State report

(1) In October 1871 fires in Grand Traverse and adjoining counties burned over 2,000,000 acres—two-thirds of population rendered homeless, several lives lost, and a number of towns wiped out.
(2) Fires in the "thumb" between Lake Huron and Saginaw Bay burned over 1,000,000 acres—138 lives lost, forests, fields, farm buildings, orchards, crops, and small villages left in ashes.
(3) Hardly a county in Upper and Lower Michigan that did not have a disastrous forest fire.
(4) Metz, Presque Isle County, destroyed.
(5) In July, Oscoda and Au Sable virtually wiped out.
(6) In July, 17 square miles of second growth in Luce County wiped out.

It was inevitable that the virgin timber should be cut. It was wholly unnecessary, however, that the cut-over lands should be made desolate. For this, fire is chiefly responsible. Under present conditions, it is estimated that the average yield per acre of cut-over land in the Lake States is only 15 to 23 cubic feet per acre per year. With adequate protection from fire this would increase to from 20 to 40 cubic feet per acre per year, while under intensive management an average of 35 to 80 cubic feet per acre per year could reasonably be expected.

The virgin forests that once covered the state can never be restored nor is it desirable that they should be wherever the land can be put to more productive use. It is desirable, however, that the idle cut-over land not needed for other purposes be put to work growing another crop of timber and that the handicap of fire be removed so that such lands may be reasonably productive.

Of importance second only to that of putting the idle forest lands of the State to work and of growing timber for present and future needs, is the desirability of reestablishing a forest cover on cut-over land for the protection of the soil, the regulation of streamflow, the conservation of wild life, and the recreational use of the State's rapidly growing urban population.

The reestablishment of a forest cover would also go a long way toward solving the economic problems of the cut-over land country by increasing taxable values, providing a permanent supply of raw materials for wood-

using industries, furnishing employment for the local population, encouraging tourist travel, and stimulating business generally. Furthermore, it would help solve the fire problem by reducing the fire hazard and making such fires as do occur easier to control.

Is Protection from Forest Fires Possible?

In the days when logging was at its height and for years thereafter, forest fires were considered inevitable and little was done to prevent or stop them except when lives or improvements were threatened. Experience has shown, however, that forest fires can be greatly reduced in size, if not in number, and those that do occur prevented, for the most part, from doing any great amount of damage. While complete protection will probably not be secured until forest lands generally are placed under management for timber production, organized state and local effort can accomplish a great deal. When timber growing becomes established as a business, protection from fire will become incidental to other forest activities. In the meantime, organized state effort is necessary as a matter of public safety and in order to make timber growing possible.

Development of State Protective Effort.

As early as 1817 legislation was passed looking to the prevention of forest fires. In 1846 a penalty was provided for the setting of fires on state land. In 1873 legislation fixing the responsibility of railroads for fires set by their locomotives was enacted. In 1897 township boards were authorized to declare a closed season during which burning could be done only under permit, and in 1893 a comprehensive forest fire law was adopted providing for the protection of forest land north of Range 20 and for the appointment of a Chief Fire Warden. Not until 1907, however, was an appropriation made for this purpose. The present forest fire law passed in 1923 and amended in 1927, extends protection to the entire state and is an outstanding example of progressive forest fire legislation.

In 1911 Congress passed what is known as the Weeks Law which, among other things, provided for the allotment of federal funds to supplement state appropriations for forest fire prevention and suppression on the watersheds of navigable streams. This law was superseded in 1923 by the Clark-McNary Act which increased and broadened the scope of the cooperation offered. The assistance thus afforded has greatly stimulated state effort. Michigan was one of the first states to qualify for federal cooperation under these laws, and today receives the maximum allotment available.

State and federal funds, available and expended by fiscal years, are shown in Table 2.

TABLE 2.—APPROPRIATIONS AND EXPENDITURES FOR THE PROTECTION OF FOREST LANDS FROM FIRE BY FISCAL YEARS—MICHIGAN, 1913-1930.

Year.	State Appropriations.	Federal Allotment.	Expenditures.		
			State.	Federal.	Total.
1913	$10,000	.....	$8,757.93	.....	$8,757.93 (1)
1914	10,000	$5,000	11,222.95	$0.50	11,223.45
1915	10,000	4,500	10,153.84	1,570.00	11,723.84
1916	20,000	4,500	41,840.27	1,134.00	42,974.27
1917	20,000	4,500	35,173.48	4,197.00	39,370.48
1918	40,000	4,500	66,098.25	3,555.00	69,653.25 (2)
1919	40,000	4,500	60,917.99	4,280.50	65,198.49 (2)
1920	50,000	4,500	60,586.46	2,110.00	62,696.46 (3)
1921	50,000	25,000	90,344.38	7,240.00	97,584.38 (3)
1922	75,000	25,000	140,367.48	25,000.00	165,367.48 (3)
1923	75,000	24,000	138,502.03	22,285.92	160,787.95 (3)
1924	225,000	22,200	241,691.76	22,163.87	263,855.63 (3)
1925	225,000	19,875	342,258.33	23,935.00	366,193.33 (3)
1926	250,000	37,080	206,003.74	48,310.00	254,313.74 (3)
1927	250,000	37,080	345,503.45	37,080.00	382,583.45 (3)
1928	302,800	58,104	304,311.00	54,804.00	359,115.00 (3)
1929	384,300	96,194	307,506.00	77,694.00	385,200.00 (4)
1930	318,300	83,355	487,982.00	81,410.00	569,392.00 (4)

(1) Fire-fighting expenses shared by State and Township (Ratio 3:1)—State share paid from general fund. (Act 249, P. A. 1903; Am. 1917, Act 364.)
(2) Emergency expenditures limited to $40,000.
(3) Emergency fund of $50,000 provided for fire fighting.
(4) Emergency expenditures paid form the general fund.

Scope and Purpose of the Present Report.

With the growth and development of organized protection, the need has arisen for reliable and specific information on which to base effective action. The purpose of the present publication is to bring together available data as to conditions involved and to present the results of an analysis of some fifteen thousand individual forest fire reports made by the Lake States Forest Experiment Station in cooperation with the Department of Conservation.

While much can be learned from the analysis in question, it should not be taken as a picture of current conditions in view of the rapid development and expansion of the State's protection effort during the past few years. It must also be borne in mind that the value of the conclusions reached is limited by the reliability and completeness of the reports in question. The importance of complete and dependable fire reports can not be over emphasized.

Since the present analysis was undertaken, there has been a vast improvement in the character of the reports submitted. For this reason the earlier figures are not always strictly comparable with those for later years. On the whole, however, the data presented gives a fair picture of conditions during the period covered and serves to point out many significant facts in regard to the forest fire situation. In connection with similar analyses of subsequent periods, it will also serve as a basis for judging the progress made toward adequate protection.

PART I

PHYSICAL AND ECONOMIC CONDITIONS

Topography.

Michigan in general is flat or rolling. Only the western part of the Upper Peninsula along the shore of Lake Superior and inland to the west of Marquette, in what are known as the Iron Ranges, are the hills sufficiently rugged to be classed as mountainous. In elevation the state ranges from 572 feet the elevation of Lake Erie, to 2,023 feet in the Iron Range of the Upper Peninsula. The bulk of the State lies between 600 and 1,000 feet although the average elevation of the protected area is in the neighborhood of 1,000 feet since it includes most of the highland of the State.

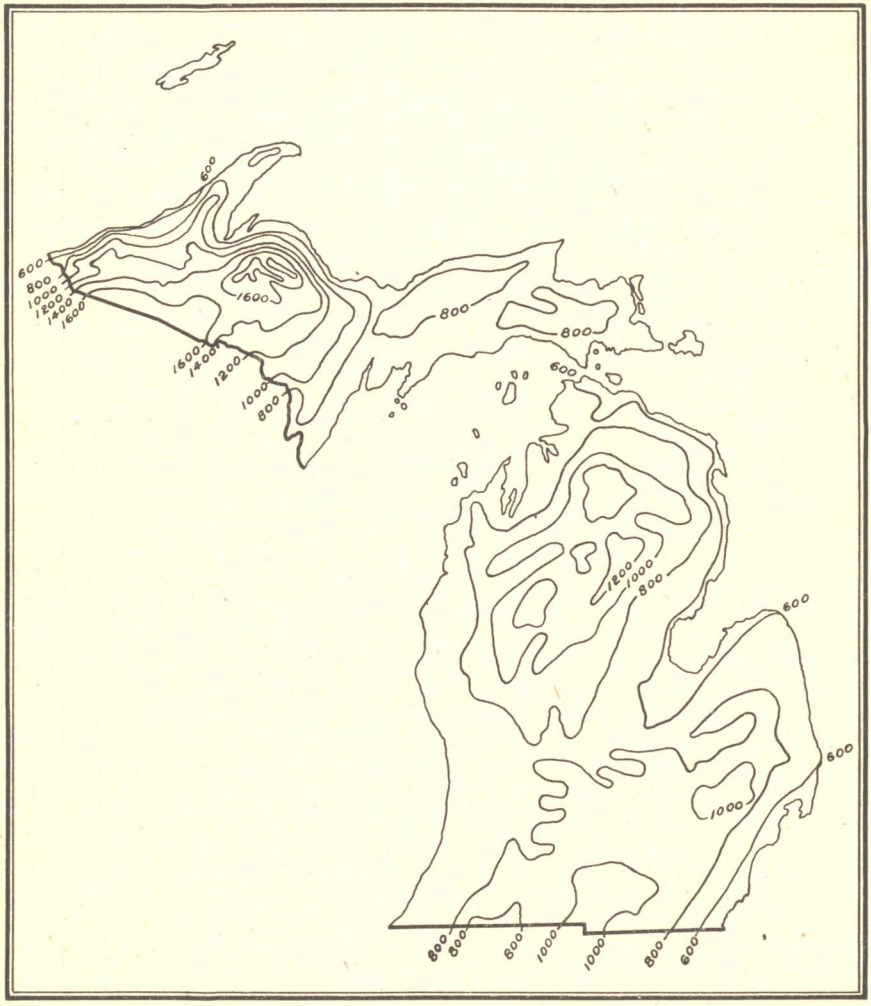


FIGURE I.—TOPOGRAPHY—MICHIGAN. (Elevation in feet above sea level.)

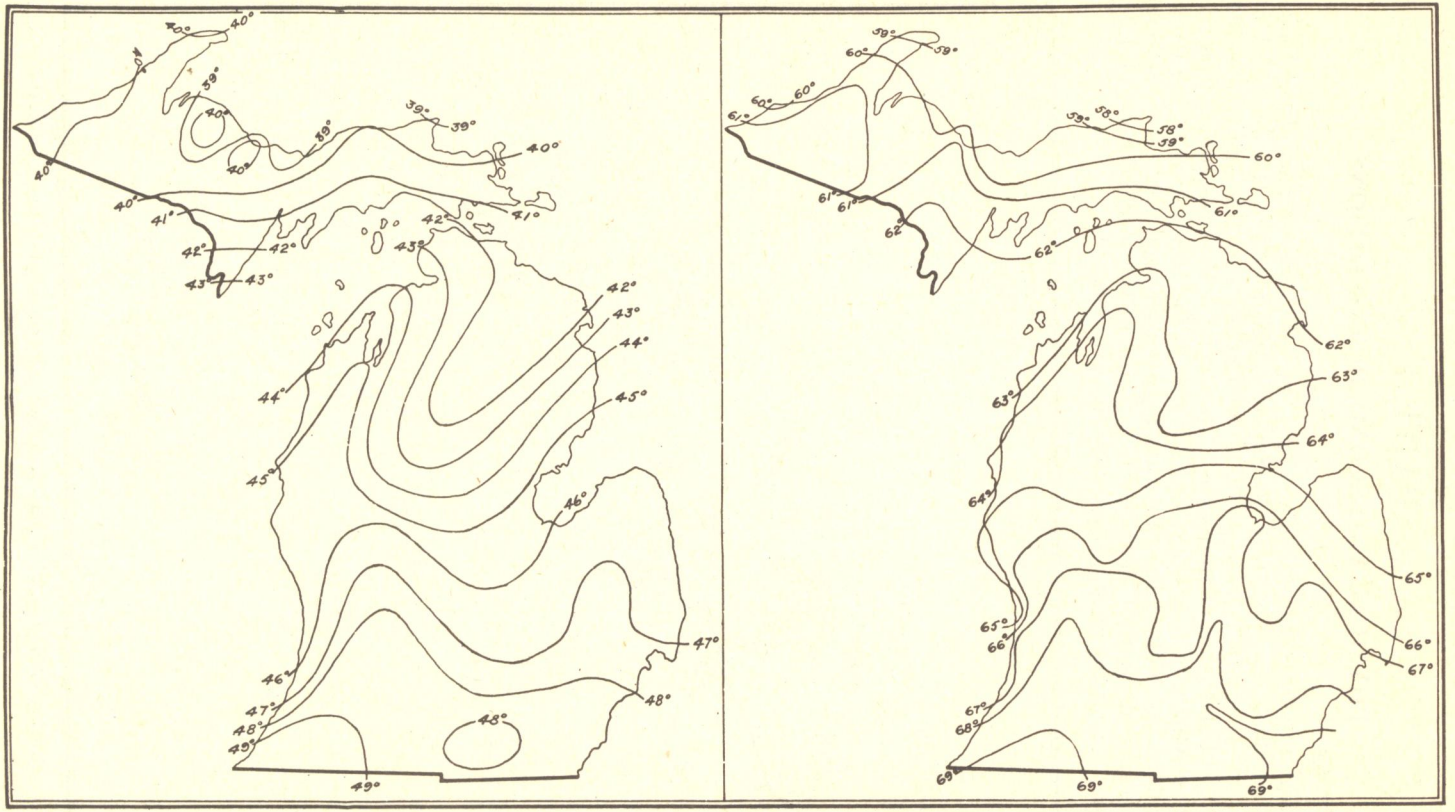


FIGURE 2.—MEAN ANNUAL TEMPERATURES—MICHIGAN.
(After D. A. Seeley, U. S. Weather Bureau.)

FIGURE 3.—MEAN SUMMER TEMPERATURES—MICHIGAN.
(After C. G. Bates, U. S. Forest Service.)

While elevation modifies climate to a certain extent, a drop of approximately 1° in the mean annual temperature for each 300-foot rise in elevation being noted, elevation and direction of slope or exposure in Michigan is of minor importance from the standpoint of forest fires. Much more important is the modifying effect of latitude and the proximity of the Great Lakes which modify the climate materially in their vicinity and hence directly affect the occurence and duration of the fire season locally.

*Climate.**

The climate of Michigan varies considerably owing to the influence of the Great Lakes and to the fact that the State lies in the path of most of the great storm centers and high pressure areas that cross North America. The effect of the Great Lakes which nearly surround both Upper and Lower Michigan is to modify the climate in their vicinity by raising the temperature in winter and lowering it in summer, thus giving to the region along their shores an equitable climate. Further inland their influence is less pronounced and the climate is more continental in character with high summer and low winter temperatures. The effect of the Lakes on the mean annual temperature is less marked as shown by Figure 2, latitude and elevation being the chief determinating factors in this case.

As Figures 2 and 3 show, the mean annual temperature as well as the summer mean increases about 10° from north to south due to the difference in latitude. The effect of elevation is also noticeable, the areas of greatest elevation being, as a rule, somewhat cooler.

Michigan lies almost entirely between 42° and 47° north latitude. The average temperature for the year ranges from 38° F in the interior of the Upper Peninsula, to 40° F in the extreme southern counties. July is normally the hottest month with August a close second, and February the coldest. The mean summer maximums in the Upper Peninsula range from 67.5° to 80.6°, and in the Lower Peninsula from 74.0° to 86.0° depending upon the proximity of one or the other of the Great Lakes.

While temperatures of 100° or more are not uncommon in the interior during July and August, it seldom exceeds 90° in the vicinity of the lakes. In winter the reverse is true, the mean minimum temperatures ranging from —1.5° to 13.4° for the Upper, and from 4.6° to 17.3° in the Lower Peninsula for interior and lake shore stations respectively. Sub-zero temperatures are common at interior stations in both Peninsulas, but it seldom goes below zero in the vicinity of the lake shores.

More important from the standpoint of forest fires than temperature perhaps, is the average date of the last killing frost in the spring and that of the first killing frost in the fall since this, to a large extent, limits the growing season and hence has an important bearing on the fire season. Here again the influence of the Great Lakes is evident as will be seen from Figures 4 and 5 which give the approximate dates of the last killing frost in spring and that of the first in the fall for different parts of the State. Latitude is also a factor in this connection. Thus in the Upper Peninsula the last killing frost in spring occurs about May 20 along the lake shore but as late as the middle of June in the interior while in the Lower Peninsula the corresponding dates are May 1 to 20 along the lakes and May 20 or later in the interior.

*Dewey A. Seeley, Meteorologist, U. S. Weather Bureau, State Department of Agriculture, Bulletin No. 3. "Climate."

Weather Bureau, U. S. Department of Agriculture, Sections 61, 62, and 63. "Summary of the Climatological Data for the United States."

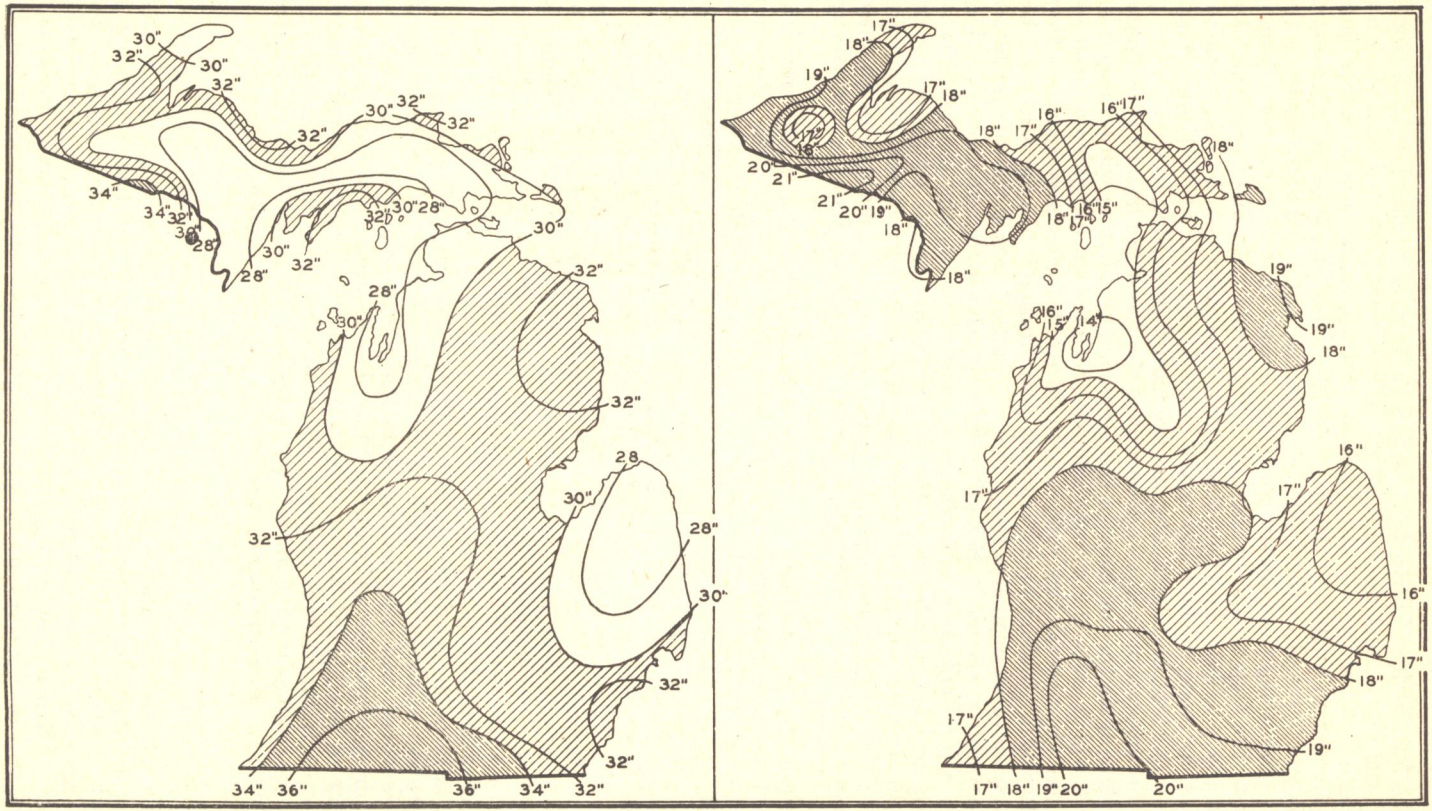


FIGURE 6.—MEAN ANNUAL PRECIPITATION—MICHIGAN. (After D. A. Seeley, U. S. Weather Bureau.)

FIGURE 7.—MEAN SUMMER RAINFALL (April to September inclusive)—MICHIGAN. (After D. A. Seeley, U. S. Weather Bureau.)

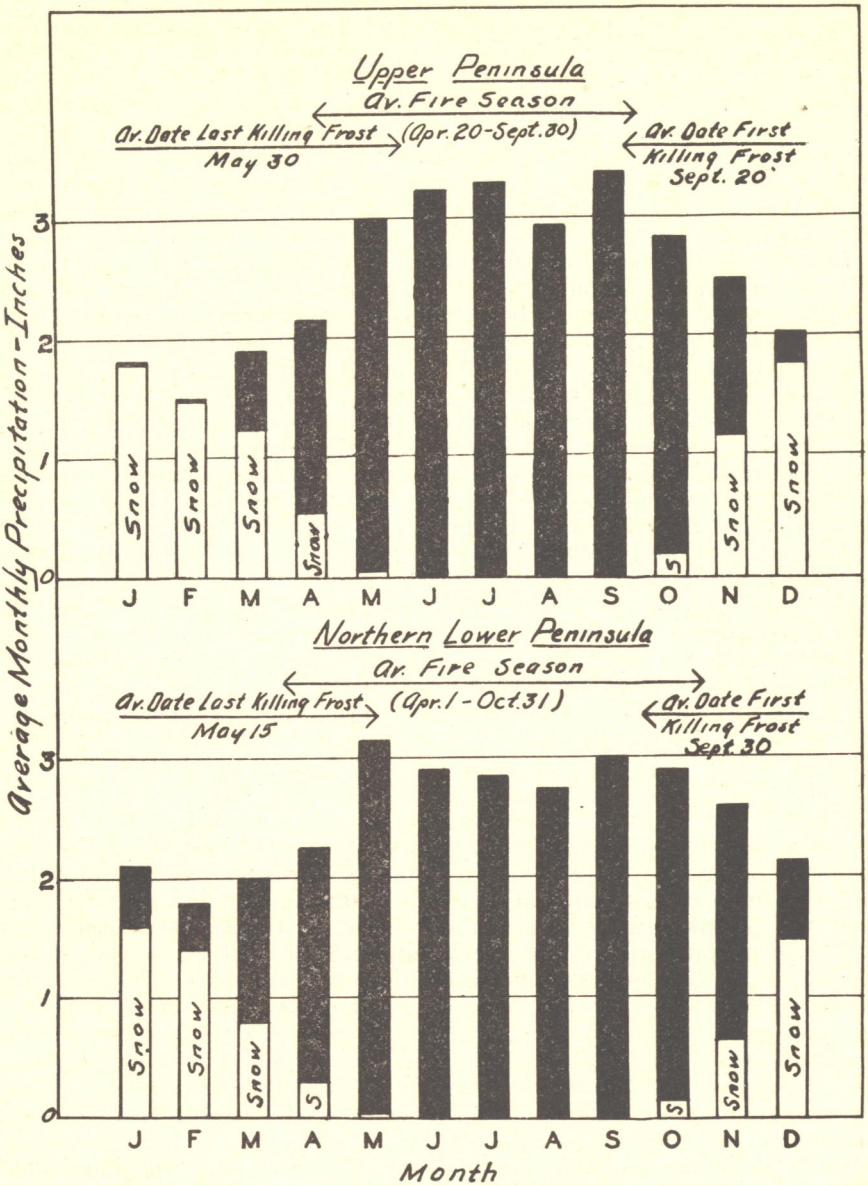


FIGURE 8.—AVERAGE MONTHLY PRECIPITATION—MICHIGAN. (U. S. Weather Bureau data.) (a) UPPER PENINSULA. (b) NORTHERN LOWER PENINSULA.

stormy weather. The high pressure areas or anti-cyclones as they are called, are most to be feared since they result in clear drying weather which, if prolonged, produce conditions favorable to the occurrence and spread of forest fires. On the other hand the storm or low pressure areas usually bring relief in the form of cloudy weather, high humidity, and more or less precipitation, although in summer this occurs usually as thunderstorms

which are often local and not of sufficient amount or duration to afford general or prolonged relief.

Soil.

From the standpoint of forest protection, the character of the soil is important since within a given climatic region it very largely determines the forest type prevailing. It also influences the moisture condition and hence the inflammability of the forest fire fuels overlaying it.

Lying as it does within the glaciated region, Michigan has a great variety of soils very much intermingled. From a protection standpoint, however, but three broad types need be recognized. (1) Sandy and gravelly soils which dry out quickly after rains and favor more or less pure stands of pine, chiefly jack and Norway. Such soils favor the rapid drying out of the forest litter and hence, a high fire hazard. (2) Loam and clay soils which tend to retain moisture and favor broadleaved trees or mixed stands of hardwoods and conifers. Such soils tend to retard the drying-out of the forest litter and by so doing reduce the fire hazard appreciably. (3) Swamp soils, rich in organic matter and normally wet, which favor such trees as black spruce, tamarack, cedar, and swamp hardwoods'—types of relatively low hazard. The latter soil type is particularly important in the Upper Peninsula where large areas are involved. In the northern part of the Lower Peninsula and along the shores of the Great Lakes, sandy soils predominate over large areas. In general, the hills, for the most part morainic in character, except in the Iron Ranges, are of heavy soil while the more level portions of the State are inclined to be sandy or swampy. An exception to this is to be noted along present and ancient lake shores where sand hills or dunes of considerable size are common.

Forest Types.

Except for a few small prairies and marsh areas, Michigan at one time was completely forested. As shown in Figure 9, hardwoods predominated in the south and conifers, and mixed hardwoods and conifers in the north. The hardwood or oak-hickory type originally covering the southern part of the State consists primarily of oak, beech, birch, maple, hickory, basswood, and elm in varying combinations and proportions together with numerous other species such as yellow poplar, chestnut, black cherry, black walnut, butternut, hackberry, ironwood, etc. The region covered by this type is today largely in farms, the remnants of forest left being confined to farm woodlots. Except in spring and fall, the fire hazard in this type is normally low. When the trees are bare, however, the forest litter drys out readily and fires are not uncommon.

North of the line marking the southern limit of commercial pine stands, three major forest types are to be found, viz., northern hardwood, pine, and swamp. The forest found on the heavier soil consists typically of beech, yellow birch, maple, and hemlock in varying proportions together with an admixture of basswood and elm in places. Originally this type contained a considerable quantity of white pine. Little of this species remains, however, the bulk of it having been removed in early logging operations. Where this type has been cut clean, it has been followed by second-growth in which hard maple predominates or in the case of fires by popple (aspen), white birch, hazel, and fire cherry. As in the hickory type to the south, the fire

danger in the beech-birch-maple-hemlock type is largely confined to spring and fall when the trees are bare and the accumulated leaf litter is exposed to the drying action of sun and wind. During extended drought periods, however, fires will run in this type even in summer. This is particularly true on recently cutover areas where the lack of a forest canopy allows the leaf litter and undecomposed slash to dry-out rapidly.

FIGURE 9.—ORIGINAL FORESTS OF MICHIGAN.

The pine type found on the lighter soils in the northern part of the State consisted originally of white, Norway, and jack pine, white pine predominating on the better and jack pine on the poorer sites. Today the white and Norway pine has practically all been cut, jack pine alone remaining in any

considerable quantity. Where unburned, second-growth Norway pine has come in together with a little white pine. For the most part, however, this type, through repeated fires, has been succeeded by jack pine, scrub oak, birch, and aspen, or has been reduced to "barrens."

The pine type presents by far the greatest fire hazard since it dries out readily and is highly inflammable. As a result fires will run in it, any time of the year after a few days of dry weather. Crown fires also are common, particularly in second-growth. When these occur, complete destruction of the stand usually results. Since the pines of the Lake States reproduce only from seed, the destruction of advance reproduction by fire is particularly serious for, unless enough seed-bearing trees remain to re-seed the area, pine is eliminated. The persistence of jack pine in spite of repeated fires is explained by its habit of retaining a portion of its cones unopened for years. When the trees are fire-killed, these cones open and furnish seed for another crop. If burned before the trees have reached seed-bearing age, however, even jack pine is eliminated and the pine barrens typical of the region result.

The swamp type varies all the way from open marsh and muskeg to dense stands of black spruce or tamarack, cedar, and balsam in varying proportions together with soft maple, alder, black ash, and an occasional white pine on the better drained sites. In general, the fire hazard in this type is low or absent altogether, except in unusually dry seasons. When fires can run in this type, however, they are most destructive usually developing into crown and ground fires which kill the stand completely and do great damage to the soil itself. Slash areas in this type are particularly dangerous in dry seasons owing to the enormous amount of slash and young growth present.

Cover Conditions.

Next to undrained swamps, virgin timber presents the lowest fire hazard. Partially cut and second-growth areas come next while recently cut-over areas with their lack of shade and large accumulation of inflammable refuse constitute the maximum hazard. In other words, fire hazard varies inversely with the density of the forest cover, and directly with the amount of combustible material present. Thus logging, fire, disease, insects, and storms all tend to increase the fire hazard to the extent that they open up the stand and increase the amount of combustible material.

Age as reflected in the size and form of the trees making up a stand is also an important factor in determining fire hazard, the hazard in even-aged stands decreasing as the trees mature. All aged stands, on the other hand, while less subject to fire than young even-aged stands, present a higher hazard than mature even-aged stands since the younger trees present frequently serve to carry fire into the crowns of the larger trees.

Land Ownership.

By far the greater part of the 20,650,000 acres of forest land in Michigan in need of protection from fire are privately-owned. At present, less than 10 per cent, or approximately 2,025,000 acres belongs to the State and Federal governments. Of this, about 291,000 acres are in national forests* and 676,500 in state forests, parks and game refuges. The balance consists for the most part of small, more or less scattered tracts of public domain and

*Note:—The present Federal land acquisition program contemplates the purchase of not to exceed 1,000,000 acres of state and privately-owned land in Alcona, Alger, Chippewa, Crawford, Delta, Iosco, Ogemaw, Oscoda, Roscommon, Schoolcraft, and possibly Iron counties for National Forests.

land that has reverted to the State for taxes. Of the 18,625,000 acres privately-owned, approximately 1,500,000 consist of woodland and woodland pasture on farms lying outside of the organized protection districts, leaving 17,125,000 acres of privately-owned land under organized protection. In size these private holdings range all the way from a few acres in the case of farm woods to a million acres or more in the case of certain large corporations. The number of individual and corporate land owners is difficult to estimate. It is, however, enormous. This diversity of ownership and the consequent diversity of interests represented, seriously complicates the problem of protection. It precludes also, the possibility of successful private protective effort except in the case of farm woods or of large compact holdings. For this reason as well as from the standpoint of public interest in the protection of the State's present and potential forest resources, state effort is essential to make protection from forest fires effective.

Liability.

From a financial standpoint, protection costs must be justified by the destructible values involved. In the case of protection from forest fires this includes merchantable standing timber, reproduction or second-growth, improvements, equipment, forest products (cut but still in the woods), the value of leaf litter as a mulch and fertilizer, and a host of intangibles such as the value of forest cover for watershed protection, as game cover, for recreation, and for scenic beauty. To these must also be added the value of personal safety to settlers and tourists or sportsmen who inhabit or frequent the forest regions of the State. What all this amounts to can probably never be satisfactorily reduced to dollars and cents. Some idea of the tangible values at stake, however, can be arrived at by an inventory of the physical property involved.

Until the present land and economic survey is completed, this can only be approximated. It has been estimated, however, that somewhat less than 8 per cent of the original stand or approximately 27½ billion feet of saw timber was left at the end of 1926. Of this the Upper Peninsula had about 19 billion, the northern portion of the Lower Peninsula 2½ billion, and southern Michigan 6 billion, the latter chiefly in farm woodlots. The merchantable timber now standing in the 46 northern counties, including cordwood at present stumpage prices, is worth not less than $250,000,000. In addition, cordwood and second-growth stands of which there are approximately 7,000,000 acres, are producing on the average under present conditions, about 20 cubic feet per acre per year, or roughly 1,500,000 cords or 750,000 M feet board measure. At present cordwood stumpage prices, this annual wood production alone is worth over a million and a half dollars which, capitalized at 3 per cent, places the present timber production value of these second growth lands at $50,000,000. Adding this to the value of the standing timber, we have a present liability of approximately $300,000,000 in destructible forest values alone. The estimated cost of adequate protection, on the other hand, in the judgment of the State and Federal forest services, is about $500,000. This is less than two-tenths of one per cent of the forest values involved, or approximately 2.6c per acre.

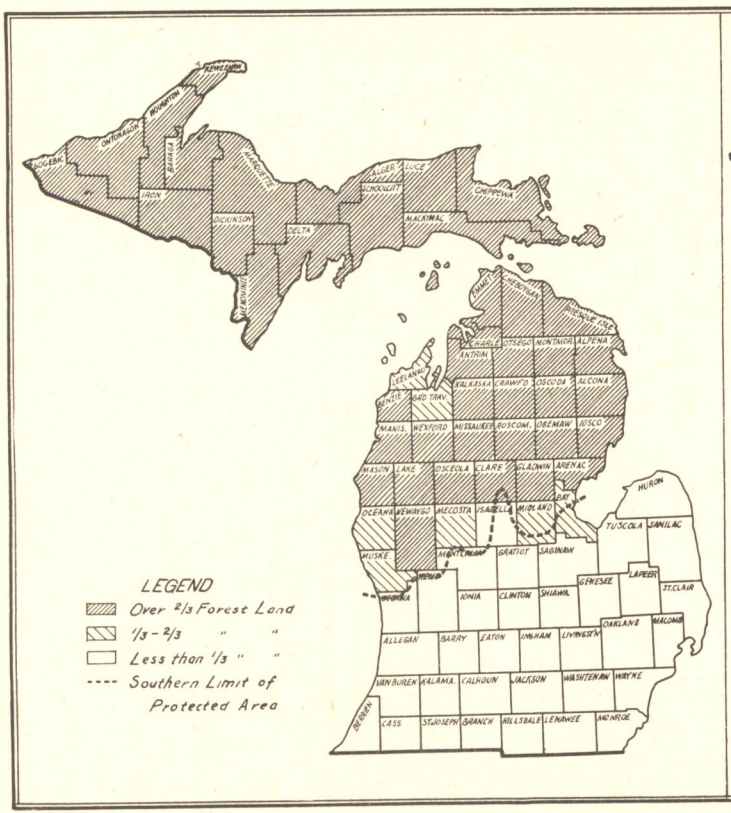


FIGURE 10.—FOREST LAND BY COUNTIES—MICHIGAN.
(1925 Agricultural Census and H. J. Andrews, Michigan Department of Conservation.)

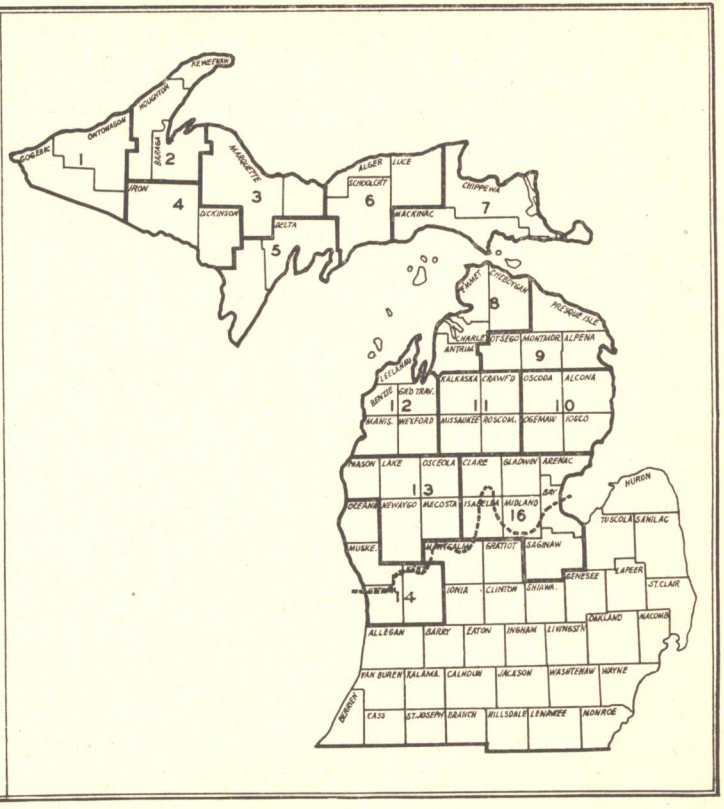


FIGURE 11.—STATE PROTECTION DISTRICTS—MICHIGAN. 1927.

AREA IN NEED OF PROTECTION

Of Michigan's total land area of 36,787,200 acres, approximately 56 per cent, is today classified as forest or wild land and is in need of protection from forest fires. The bulk of this land lies in the Upper Peninsula and in the north half of the Lower Peninsula as shown in Figure 10.

For the most part, it consists of cut and burned-over timber land more or less broken up by settlement and cultivation. In the Upper Peninsula, there are still considerable areas of virgin timber. In the southern part of the Lower Peninsula, on the other hand, the forest land remaining is confined largely to small scattered tracts of farm woods and woodland pasture.

Obviously the need for organized protection is most urgent where settlement is scattered and forest land predominates. This has been recognized in the establishment of protection districts as shown in Figure 11.

Within the organized protection districts, approximately 19¼ million acres or 87 per cent of the total area is forest land. Outside, less than 10 per cent of the land is in need of protection. The area in need of protection by counties is shown in Table 3, while Table 4 gives the same data by protection districts and for the protected area as a whole.

TABLE 3.—AREA IN NEED OF PROTECTION BY COUNTIES—MICHIGAN 1927.

County.	Total Land Area (Acres)*	Area in Need of Protection** (Acres).	Per Cent of Total Area in Need of Protection.
Alcona	437,760	391,920	89.5%
Alger	588,800	571,640	97.1
Allegan	533,120	56,100	10.5
Alpena	373,760	316,520	84.7
Antrim	304,000	225,020	74.0
Arenac	239,360	174,960	73.1
Baraga	586,880	564,920	96.3
Barry	355,840	39,820	11.2
Bay	283,520	122,820	43.3
Benzie	200,960	158,160	78.7
Berrien	364,160	29,580	8.1
Branch	318,080	30,560	9.6
Calhoun	443,520	33,860	7.6
Cass	315,520	29,020	9.2
Charlevoix	263,040	191,140	72.7
Cheboygan	464,000	412,100	88.8
Chippewa	1,006,720	891,520	88.6
Clare	372,480	290,640	78.0
Clinton	365,440	34,300	9.4
Crawford	368,000	356,880	97.0
Delta	748,160	685,780	91.7
Dickinson	496,640	477,640	96.2
Eaton	365,440	34,520	9.4
Emmet	310,400	251,160	80.9
Genesee	419,200	39,560	9.4
Gladwin	332,160	264,780	79.7
Gogebic	725,120	704,320	97.1
Grand Traverse	298,880	197,020	65.9
Gratiot	370,560	44,920	12.1
Hillsdale	382,080	39,000	10.2
Houghton	652,160	582,620	89.3
Huron	546,560	58,640	10.7
Ingham	353,920	32,490	9.2
Ionia	370,560	33,820	9.1
Iosco	364,800	320,740	87.9

TABLE 3.—AREA IN NEED OF PROTECTION BY COUNTIES—MICHIGAN 1927.—Concluded.

County.	Total Land Area (Acres)*	Area in Need of Protection** (Acres).	Per Cent of Total Area in Need of Protection.
Iron	768,000	745,460	97.1%
Isabella	366,080	113,620	31.0
Jackson	452,480	38,820	8.6
Kalamazoo	359,680	19,580	5.4
Kalkaska	366,720	319,600	87.2
Kent	550,400	77,760	14.1
Keweenaw	354,560	349,240	98.5
Lake	370,560	336,080	90.7
Lapeer	426,240	40,840	9.6
Leelanau	216,320	135,640	62.7
Lenawee	475,520	48,580	10.2
Livingston	363,520	37,100	10.2
Luce	588,800	576,260	97.9
Mackinac	668,160	637,180	95.4
Macomb	302,080	31,700	10.5
Manistee	359,680	279,740	77.8
Marquette	1,196,800	1,156,280	96.6
Mason	316,160	211,340	66.8
Mecosta	365,440	216,280	59.2
Menominee	675,840	583,840	86.4
Midland	338,560	145,840	43.1
Missaukee	372,480	294,840	79.2
Monroe	366,720	26,700	7.3
Montcalm	463,360	92,520	20.0
Montmorency	359,040	335,340	93.4
Muskegon	322,560	198,820	61.6
Newaygo	544,640	405,920	74.5
Oakland	567,040	50,600	8.9
Oceana	347,520	212,080	61.0
Ogemaw	371,200	314,180	84.6
Ontonagon	853,120	816,380	95.7
Osceola	369,280	253,900	68.8
Oscoda	368,640	353,880	96.0
Otsego	337,920	306,700	90.8
Ottawa	361,600	56,530	15.6
Presque Isle	433,920	382,600	88.2
Roscommon	344,320	334,820	97.2
Saginaw	529,920	69,520	13.1
St. Clair	454,400	42,400	9.3
St. Joseph	321,920	21,020	6.5
Sanilac	624,640	58,120	9.3
Schoolcraft	772,480	749,000	97.0
Shiawassee	356,480	32,880	9.2
Tuscola	529,280	64,480	12.2
Van Buren	394,880	36,060	9.1
Washtenaw	450,560	40,420	9.0
Wayne	396,800	23,800	6.0
Wexford	369,280	292,300	79.2
Upper Peninsula	10,682,240	10,092,080	94.5%
Lower Peninsula	26,104,960	10,563,000	40.5%
State Total	36,787,200	20,655,080	56.1%

*1925 Agricultural Census.
**1925 Agricultural Census and H. J. Andrews, Michigan Department of Conservation.

TABLE 4.—AREA IN NEED OF PROTECTION BY STATE PROTECTION DISTRICTS—MICHIGAN 1927.

(State and National Forest Land Included)

District.	Total Land Area (Acres)	Area in Need of Protection. (Acres)	Per Cent of Total Area in Need of Protection.
1	1,578,240	1,520,700	96.4%
2	1,593,600	1,496,780	93.9
3	1,535,800	1,485,320	96.7
4	1,264,640	1,223,100	96.7
5	1,424,000	1,269,620	89.2
6	1,611,080	1,567,860	97.3
7	1,674,880	1,528,700	91.3
8	1,341,440	1,079,420	80.5
9	1,504,640	1,341,160	89.1
10	1,542,400	1,380,720	89.5
11	1,451,520	1,306,140	90.0
12	1,445,120	1,062,860	73.5
13	1,966,080	1,423,520	72.4
*14	692,000	458,240	66.2
*15	101,460	49,420	48.7
*16	1,363,580	1,030,240	75.6
Upper Peninsula	10,682,240	10,092,080	94.5%
Lower Peninsula	11,408,240	9,131,720	80.0%
Total	22,090,480	19,223,800	87.0%

*Figures for part under organized protection.

PART II

SIZE AND IMPORTANCE OF THE FIRE PROBLEM

Number of Fires.

The number of fires that occur annually indicates the size, while the area burned and loss sustained indicate the importance of the forest fire problem. As conditions, however, vary widely from year to year, it is not safe to judge the situation by the record of any one year no matter how complete and accurate the record may be. On the other hand, average conditions fail to indicate what is to be expected in years of extreme hazard. To properly size up the situation both average and extreme conditions must be taken into consideration.

Based on the records for the five years ending with 1927 which were the best available at the time this study was undertaken, it would appear that the average number of fires to be expected annually is well over 2,000. Allowing for the probable incompleteness of returns during the earlier years of the period in question, it is safe to assume that 2,500 is not far from the true average. This figure, therefore, represents the minimum number of fires that the protective organizations within the State must be prepared to cope with annually. As pointed out, however, there is a wide variation from year to year in the number of fires that actually occur. (See Figure 12-a) During the period in question, this ranged from 1,336 in 1923 to nearly 4,000 in 1925. To adequately meet the situation, therefore, the protective organization must not only be prepared to handle average conditions but, on short notice, to expand sufficiently to carry approximately twice the normal load. To do this efficiently, in the time required to be effective, is one of the chief problems of protection administration and the reason why ample funds over and above normal requirements must be available if adequate protection is to be afforded when emergency conditions arise.

Whether the average number of fires per year is increasing or decreasing is hard to say. On the face of the returns there was a 200 per cent increase in the average number of fires for 1923 to 1927 over 1918 to 1922. While this is accounted for primarily by the admittedly incomplete returns for the earlier period, it is probable that there has been, and will continue to be an appreciable increase in the average number of fires per year due to the increasing number of tourists and campers in the woods as a result of the recreational development of northern Michigan. Eventually this should be offset by education and other fire prevention measures. For the present, however, it must be taken into consideration in planning protective effort.

Area Burned.

The average area burned over annually from 1923 to 1927 inclusive was close to 350,000 acres. Like *number of fires* the area burned over annually varies widely from year to year, 1925 being the peak year with close to 750,000 acres burned over. Unlike *number of fires* however, there has been, with the exception of 1925, a steady decrease in the area burned each year as shown in Figure 12-b. This indicates an increase in the effectiveness of fire suppression which is confirmed by a decrease in the size of the average fire during the same period from 350 acres in 1923, to 40 in 1927 as shown in Figure 12-c. A decrease in the size of the average fire for the five-year period over the preceding five years of nearly 50 per cent is also to be noted.

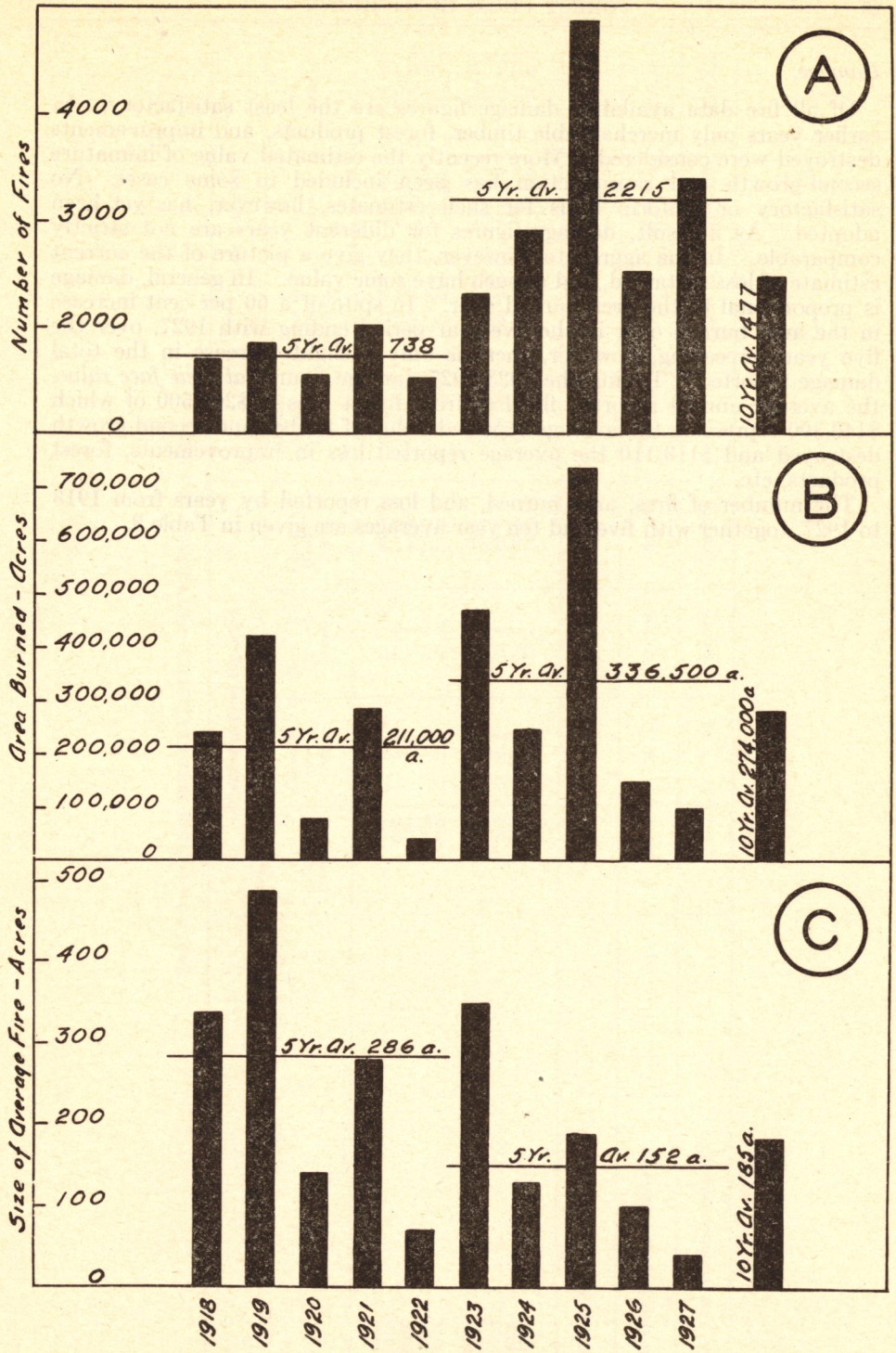


FIGURE 12.—FOREST FIRE DATA BY YEARS—MICHIGAN. 1920-1927. (a) NUMBER OF FIRES. (b) AREA BURNED. (c) SIZE OF AVERAGE FIRE.

Damage.

Of all fire data available, damage figures are the least satisfactory. In earlier years only merchantable timber, forest products, and improvements destroyed were considered. More recently the estimated value of immature second-growth and reproduction has been included in some cases. No satisfactory or uniform basis for such estimates, however, has yet been adopted. As a result, damage figures for different years are not strictly comparable. In the aggregate, however, they give a picture of the current estimate of loss sustained, and as such have some value. In general, damage is proportional to the area burned over. In spite of a 60 per cent increase in the area burned over in the five-year period ending with 1927, over the five years preceding, however, there is only a slight increase in the total damage reported. Taking the 1923-1927 damage figures *at their face value*, the average annual reported fire loss from forest fires is $266,500 of which $148,390 represents the average reported value of timber and second-growth destroyed and $118,110 the average reported loss in improvements, forest products, etc.

The number of fires, area burned, and loss reported by years from 1918 to 1927, together with five and ten year averages are given in Table 5.

TABLE 5.—FOREST FIRE STATISTICS—MICHIGAN. 1918-1927.

Year.	Number of Fires Reported.				Area Burned (Acres)	Loss Reported.		
	Total Number.	Class "A" (0—¼ Acre)	Class "B" (¼—10 Acres)	Class "C" (Over 10 Acres)		Timber and Second Growth.	Other.	Total.
1918	704	2.5%	15.5%	82.0%	238,120	$91,200	$22,980	$114,180
1919	862	4.6	24.6	70.8	418,360	216,460	190,400	406,860
1920	560	4.5	5.5	90.0	76,440	257,810	148,180	405,990
1921	1,028	1.5	22.3	76.2	283,640	222,290	74,100	296,390
1922	538	3.0	41.8	55.2	38,480	25,410	9,860	35,270
1923	1,336	2.0	26.1	71.9	466,470	255,370	279,440	534,810
1924	1,936	7.9	34.8	57.3	242,960	133,760	16,010	149,770
1925	3,887	9.2	28.3	62.5	733,750	246,500	228,610	475,110
1926	1,524	11.7	51.5	36.8	145,060	43,160	58,570	101,730
1927	2,394	10.5	59.1	30.4	94,720	63,150	7,900	71,050
5-Year Average—1918-1922	738	3.1%	21.8%	75.1%	211,010	$162,640	$89,100	$251,740
5-Year Average—1923-1927	2,215	8.7%	39.0%	52.3%	336,510	$148,390	$118,110	$266,500
10-Year Average—1918-1927	1,477	7.3%	34.7%	58.0%	273,870	$155,510	$103,610	$259,120

TABLE 5.—FOREST FIRE STATISTICS—MICHIGAN. 1918-1927—Continued.

Year.	Number of Fires Per 100,000 Acres Protected.	Size of Average Fire (Acres)	Per Cent of Protected Area Burned.	Average Loss Per Acre Burned. (Dollars)	Average Loss Per Acre Protected. (Dollars)	Average Loss Per Fire (Dollars)	Average Forest Loss Per Acre Burned. (Dollars)	Average Forest Loss Per Acre of Forest Protected. (Dollars)	Average Forest Loss Per Fire (Dollars)
	Risk of Kindling.	Risk of Spreading.	Risk of Burning.	Destructiveness.	Risk of Loss.	Risk of Loss per Fire.	Forest Destructiveness.	Risk of Forest Loss.	Risk of Forest Loss per Fire.
1918	3.9	340	1.3%	$.48	$.006	$160	$.38	$.006	$130
1919	4.8	490	2.3	.97	.023	470	.52	.013	250
1920	3.1	140	0.4	5.31	.023	720	3.37	.016	460
1921	5.7	280	1.6	1.04	.016	230	.78	.014	220
1922	3.0	70	0.2	.92	.002	70	.47	.002	50
1923	7.4	350	2.6	1.15	.030	400	.55	.016	190
1924	8.8	130	1.1	.62	.007	80	.55	.007	70
1925	17.6	190	3.3	.65	.022	120	.34	.013	60
1926	6.9	100	0.7	.70	.005	70	.30	.002	30
1927	10.8	40	0.4	.75	.003	30	.67	.003	25
5-Year Average—1918-1922	4.1	286	1.2%	$1.19	$.014	$340	$.77	$.010	$220
5-Year Average—1923-1927	10.4	152	1.6%	$.79	$.013	$120	$.44	$.008	$70
10-Year Average—1918-1927	7.5	185	1.4%	$.95	$.013	$180	$.57	$.009	$110

DISTRIBUTION AND CONCENTRATION OF FIRES

The distribution and concentration of fires is an important consideration in planning protective effort. While fires are likely to occur wherever forest land is found, the problem in general, is most acute where forest land predominates. As already pointed out, this is in the Upper Peninsula and the north half of the Lower Peninsula. Within this area, however, there is considerable variation in the concentration of fires as is shown in Figure 13.

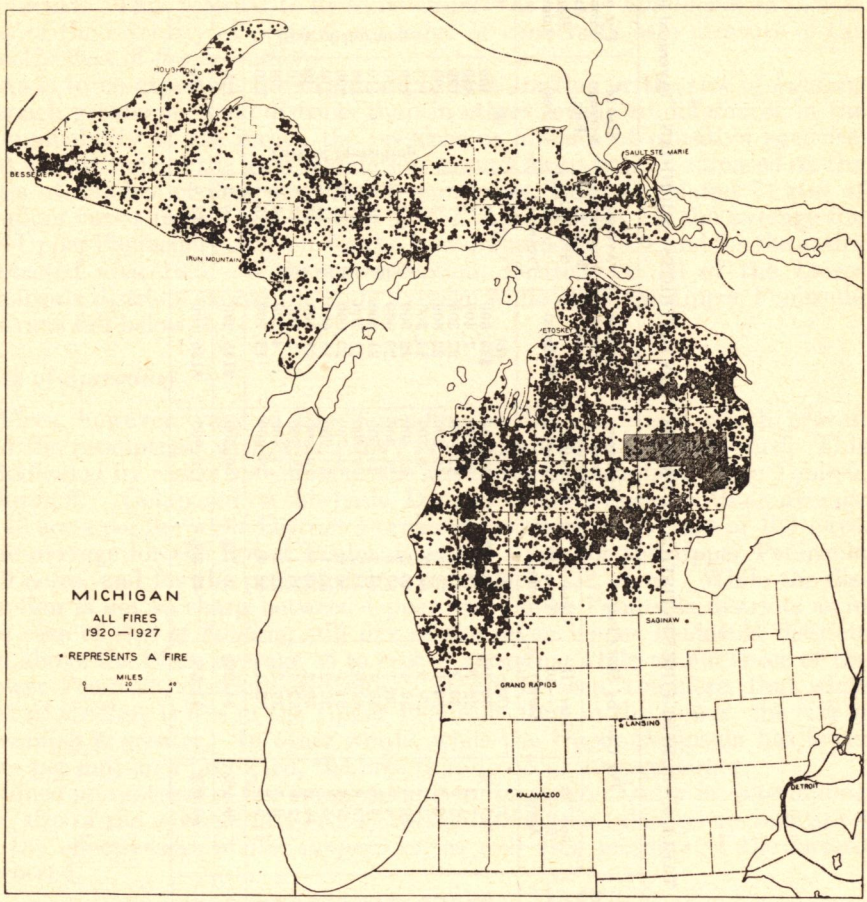


FIGURE 13.—DISTRIBUTION OF FOREST FIRES—MICHIGAN. 1920-1927

Generally speaking, this concentration is most noticeable along railroads, and in regions where logging or agricultural development is in progress.

How the various organized protection districts compare as to average annual number of fires, area burned, and loss reported based on the figures available for 1923 to 1927, inclusive, is shown in Table 6.

TABLE 6.—FOREST FIRE STATISTICS BY PROTECTION DISTRICTS—MICHIGAN. (Averaged for 1923-1927)

Protection District.	Average Number of Fires Per Year.	Per Cent by Size Class.			Average Area Burned Annually. (Acres)	Average Annual Loss (Dollars)	Average Number of Fires Per 100,000 Acres Protected.	Size of Average Fire. (Acres)	Per cent of Protected Area Burned Annually.	Average Loss Per Acre Burned. (Dollars)	Average Loss Per Acre Protected. (Dollars)
		Class "A" (0—¼ Acre)	Class "B" (¼—10 Acres)	Class "C" (Over 10 Acres)			Risk of Kindling.	Risk of Spreading.	Risk of Burning.	Destructiveness.	Risk of Loss.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	112	25.1%	36.4%	38.5%	44,500	$35,800	7.1	400	2.8%	$.80	$.023
2	61	7.3	22.7	70.0	20,700	7,400	3.8	340	1.3	.36	.005
3	114	5.9	40.9	53.2	22,000	27,300	7.4	190	1.4	1.24	.018
4	103	2.2	25.1	72.7	19,200	22,800	8.1	190	1.5	1.19	.018
5	79	3.3	29.9	66.8	8,700	14,200	5.5	110	0.6	1.63	.010
6	107	10.4	40.4	49.2	23,400	12,500	6.6	220	1.5	.53	.008
7	154	6.9	36.1	57.0	21,800	25,900	9.2	140	1.3	1.19	.016
8	226	9.6	45.7	44.7	24,500	31,600	16.8	110	1.8	1.29	.024
9	256	13.4	42.9	43.7	29,300	21,700	17.0	110	1.9	.74	.014
10	170	5.4	37.9	56.6	34,700	23,000	11.0	200	2.2	.66	.015
11	162	6.7	37.2	56.1	34,200	15,600	11.2	210	2.4	.46	.011
12	250	16.3	50.2	33.5	10,800	21,000	17.3	40	0.7	1.94	.015
13	300	12.6	52.3	35.1	15,500	5,300	15.3	50	0.8	.34	.003
14	46	8.7	39.2	52.1	4,100	4,200	6.6	90	0.6	1.02	.006
16	181	5.5	32.1	62.4	39,800	13,700	13.3	220	2.9	.34	.010
Upper Mich.	730	9.1%	34.2%	56.7%	160,300	$145,900	6.8	220	1.5%	$.91	$.014
Lower Mich.	1,591	10.6%	43.6%	45.8%	192,900	$136,100	13.9	120	1.7%	$.71	$.012

RISK

While the foregoing figures give an idea of the size and importance of the fire problem, they do not express the risk prevailing since, other things being equal, the larger the area involved the greater will be the number of fires, area burned, and loss. By dividing each of these items by the area involved, a measure of risk is obtained by which conditions can be rated and compared.

Risk of Fires Starting.

Risk of fires starting is expressed as the number of fires per year per unit area protected. This, referred to by some writers* as *risk of kindling* is an indication of the intensity of protection needed or conversely as a measure of the effectiveness of *fire prevention.*

As is to be expected, the likelihood of fires starting or the *risk of kindling* is much greater in some districts than in others, owing to differences in the inflammability of the forest, the presence or absence of causitive agencies, and the attitude of the local population toward forest fires. Compared on the basis of number of fires per 100,000 acres, (see Table 6, column 7) *risk of kindling* varies from 3.8 in District 2 to 17.3 in District 12, the average for the Upper Peninsula being 6.8, for the Lower Peninsula 13.9, and for the entire protected area 10.5. With one exception, District 14, all of the Lower Peninsula districts exceed the state average while all of the Upper Peninsula districts fall below it.

Risk of Spreading.

Fires, however, vary in size depending on the conditions which prevail and the promptness with which they are discovered and extinguished. This is indicated by *risk of spreading* or the size of the average fire. (See Table 6, column 8). Compared on this basis, District 12 ranks lowest with an average of 40 acres per fire while District 1 ranks highest with an average of 400 acres. The average for the Lower Peninsula is 120 acres, for the Upper Peninsula 220 acres, and for the protected area as a whole 152 acres. While the distinction is not so sharp between Upper and Lower Peninsula districts as in the case of *risk of kindling* still five of the seven Upper Peninsula districts are above the State average as to *risk of spreading* while all but three of the Lower Peninsula districts are below. It will be seen, therefore, that while *risk of kindling* is less in the Upper Peninsula than in the Lower, the *risk of spreading* is greater. In other words, while the Upper Peninsula has fewer fires per unit area protected, the fires that do occur average larger.

Since promptness of fire suppression is an important factor in determining the size of the average fire, *risk of spreading* may be taken as an indication of the effectiveness of *fire suppression* as well as a measure of the hazard involved.

Risk of Burning.

By dividing the average area burned annually by the area under protection, an expression of *risk* is obtained which indicates the effectiveness of protection in force. This is called *risk of burning.* For the protected area as a whole, the *risk of burning* for the period in question is 1.6 per cent, for the Upper Peninsula 1.5, and for the Lower 1.7 per cent. In other words, on the average

*Forest Fires in Finland, by Ano Saari. Publications of the Society of Forestry in Finland, Vol. 26, 1923

1.6 per cent of the total protected area burned over anunally, 1.5 per cent of the Upper Peninsula and 1.7 of the Lower. Between districts *risk of burning* is more marked, it being highest in District 16 where the average area burned over amounted to 2.9 per cent and lowest in District 5 which averaged .6 per cent as shown in Table 6, column 9.

Destructiveness.

Another important consideration is damage or loss. Obviously destructible property is not uniformly distributed. Certain forest types also are more subject to damage than others. The relative *destructiveness* of fires in different localities is, therefore, important as a guide to the proper distribution of protective effort. This may be determined by a comparison of the average loss per acre burned, providing of course, that dependable loss figures are available. As shown in Table 6, Column 10, the reported average loss per acre ranges from 34 cents in Districts 13 and 16 to $1.94 in District 12. This difference, however, may be and probably is due to a large extent, to a lack of uniformity in estimating the damage done. In general, however, it would appear that the loss per acre burned is higher in the Upper Peninsula, than in the Lower, averaging 91 and 71 cents respectively with a state average of 79.

Risk of Loss.

Risk of loss or the average annual loss per acre protected is a combined expression of *destructiveness* and *risk of burning* since it depends on both the average loss per acre and the area burned over. For the protected area as a whole, according to the data available, this amounts to $.013 per acre, averaging $.014 for the Upper and $.012 for the Lower Peninsula. District 13 with an average annual loss of $.003 per acre ranks lowest while District 8 where the average annual loss per acre amounts to $.024 is highest.

Aside from serving as a guide to the proper allotment of protection funds between districts by showing where better protection is most urgently needed, *risk of loss* gives an idea of the financial risk involved or the average cost of self insurance by protection districts. What this is for each of the protection districts is shown in Table 6, column 11.

Summary of Risk.

For convenience in comparing adjoining districts as to risk, the risk data contained in Table 6 is presented graphically in Figure 14 and the ranking of the various districts as to risk and destructivenesss of fires is given in Table 7.

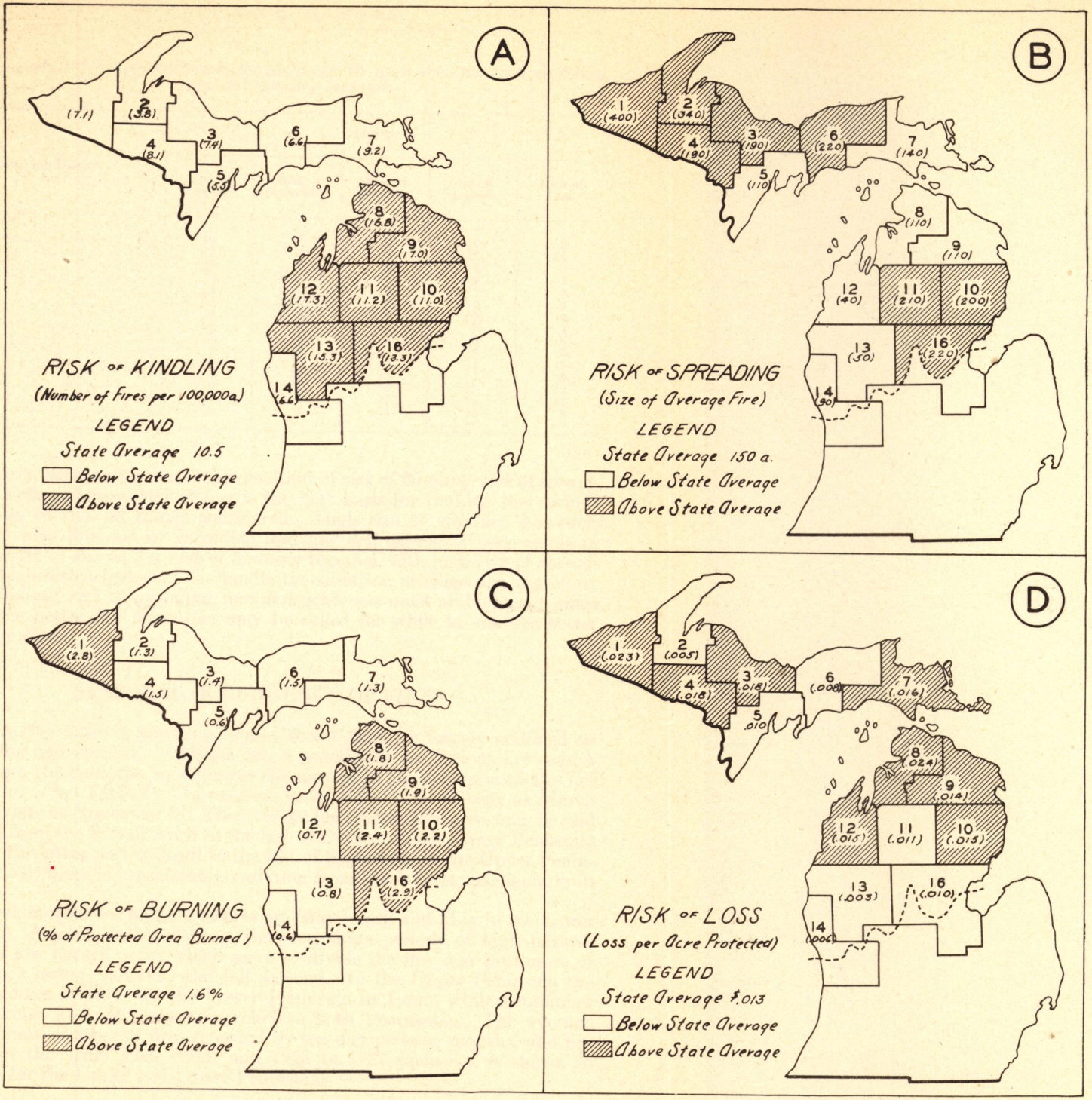


FIGURE 14.—RISK BY PROTECTION DISTRICTS—MICHIGAN. (Averages for 1923-1927, inclusive.) (a) RISK OF KINDLING. (b) RISK OF SPREADING. (c) RISK OF BURNING. (d) RISK OF LOSS.

TABLE 7.—RANKING OF PROTECTION DISTRICTS AS TO RISK AND DESTRUCTIVENESS OF FIRES—MICHIGAN. 1923-1927.

Protection District.	Rank as to—				
	Risk of Kindling.	Risk of Spreading.	Risk of Burning.	Destructiveness.	Risk of Loss.
1	10	1	2	7	2
2	13	2	9	12	11
3	10	6	8	4	3
4	9	6	7	5	3
5	12	8	12	2	8
6	11	3	7	10	9
7	8	7	9	5	4
8	3	8	6	3	1
9	2	8	5	8	6
10	7	5	4	9	5
11	6	4	3	11	7
12	1	11	11	1	5
13	4	10	10	13	12
14	11	9	12	6	13
16	5	3	1	13	8

Obviously, since *risk of loss* is the resultant of *risk of kindling*, *risk of spreading*, and *destructiveness*, *risk of loss* is the best basis for ranking the various districts as to risk all things considered. High *risk of kindling*, however, combined with low *risk of spreading* and low *destructiveness* may result in the same *risk of loss* as low *risk of kindling* together with high *risk of spreading* and high *destructiveness*. To handle the situation intelligently, therefore, *risk of kindling*, *risk of spreading*, and *destructiveness* must all be known since in one case better fire *prevention* may be called for while in another better fire *suppression*.

SEASONAL OCCURRENCE OF FIRES

While in the Lake States as a whole, forest fires are largely confined to early spring and late fall, Michigan has a practically continuous fire season lasting from the time the snow leaves the ground in the spring until the fall rains set in. (See Table 8). In extreme years, fires occur as early as March 27, and as late as November 31. The average fire season, however, may be said to extend from the first of April to the last of October in the Lower Peninsula and from the latter part of April to the last of September in the Upper Peninsula although there is considerable variation from these dates, particularly in the fall.

The peak months for number of fires are May (April and May in the Lower Peninsula), August, and October. Between these periods of high hazard, periods of low hazard occur which serve to divide the fire year into more or less distinct spring, summer, and fall seasons. In the Upper Peninsula the first lull comes in July, (in the Lower Peninsula in June), while September usually brings at least temporary relief to both Peninsulas. The average and maximum number of fires reported by ten-day periods, months, and fire seasons for the years 1920, 1921, and 1923 to 1927 inclusive, is shown in Figure 15 for the Upper and Lower Peninsulas.

TABLE 8.—SEASONAL OCCURRENCE OF FIRES BY 10-DAY PERIODS—MICHIGAN. 1923-1927.

10-Day Period.	Average.				Per Cent of Total.				Average.			
	Number of Fires.	Area Burned. (Acres)	Forest Loss. (Dollars)	Total Loss. (Dollars)	Number of Fires.	Area Burned.	Forest Loss.	Total Loss.	Size of Fire. (Acres)	Forest Loss Per Acre Burned. (Dollars)	Total Loss Per Acre Burned. (Dollars)	Total Loss Per Area Protected. (Cents)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
March 1–10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 11–20	2	10	.....	.....	0.1%	* %	.....	.....	5	.....	.....	.....
March 21–31	8	490	$60	$90	0.4	0.2	0.1%	*%	60	$.12	$.18	.....
April 1–10	104	13,210	3,030	5,600	5.1	4.3	2.7	2.9	130	.23	.42	.025
April 11–20	78	8,480	1,450	2,920	3.9	2.7	1.3	1.5	110	.17	.34	.013
April 21–30	79	6,590	1,330	2,540	3.9	2.1	1.2	1.3	80	.20	.39	.011
May 1–10	219	36,910	9,800	16,230	10.8	11.9	8.9	8.3	170	.27	.44	.073
May 11–20	195	42,110	12,360	28,690	9.6	13.6	11.3	14.7	220	.29	.68	.130
May 21–31	158	35,680	9,980	24,760	7.8	11.5	9.1	12.7	230	.28	.69	.112
June 1–10	103	11,840	6,240	7,540	5.1	3.8	5.7	3.9	110	.53	.64	.034
June 11–20	60	3,610	1,620	2,880	3.0	1.2	1.5	1.5	60	.45	.80	.013
June 21–30	83	5,670	3,720	5,860	4.1	1.8	3.4	3.0	70	.66	1.03	.027
July 1–10	100	7,560	4,630	9,210	5.0	2.4	4.2	4.7	80	.61	1.22	.042
July 11–20	77	7,440	4,160	7,340	3.8	2.4	3.8	3.8	100	.56	.99	.033
July 21–31	73	5,670	2,840	3,900	3.6	1.8	2.6	2.0	80	.50	.69	. 18
August 1–10	104	7,990	5,450	9,000	5.1	2.6	5.0	4.6	80	.68	1.13	.041
August 11–20	112	9,100	2,850	5,120	5.5	2.9	2.6	2.6	80	.31	.56	.023
August 21–31	171	22,170	12,110	17,210	8.5	7.1	11.0	8.2	130	.55	.78	.078
September 1–10	69	6,170	2,060	3,650	3.4	2.0	1.9	1.9	90	.33	.59	.017
September 11–20	25	660	40	50	1.2	0.2	*	*	30	.06	.08	.....
September 21–30	9	8,600	1,160	2,260	0.4	2.8	1.0	1.1	960	.13	.26	.010
October 1–10	32	20,920	3,910	13,140	1.6	6.7	3.6	6.7	650	.19	.63	.060
October 11–20	30	13,730	2,390	4,360	1.5	4.4	2.2	2.2	460	.17	.32	.020
October 21–31	95	30,820	17,000	20,320	4.7	9.9	15.5	10.4	320	.55	.66	.092
November 1–10	34	5,060	1,500	2,550	1.7	1.6	1.4	1.3	150	.30	.50	.012
November 11–20	1	10	.....	140	0.1	*	.....	0.1	10	.....	.....	.....
November 21–30	1	180	.....	.....	0.1	0.1	.....	.....	180	.....	.....	.....

Relative Risk of Kindling. Relative Risk of Burning. Relative Risk of Forest Loss. Relative Risk of Loss. Risk of Spreading. Forest Destructiveness. Destructiveness. Risk of Loss.

*Less than .05 of one per cent.

TABLE 8. (Continued)—SEASONAL OCCURRENCE OF FIRES BY MONTHS, AND FIRE SEASONS—MICHIGAN. 1923-1927.

Month.	Average.				Per Cent of Total.				Average.			
	Number of Fires.	Area Burned. (Acres)	Forest Loss. (Dollars)	Total Loss. (Dollars)	Number of Fires.	Area Burned.	Forest Loss.	Total Loss.	Size of Fire. (Acres)	Forest Loss Per Area Burned. (Dollars)	Total Loss Per Area Burned. (Dollars)	Total Loss Per Area Protected. (Cents)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
March	10	500	$60	$90	0.5%	0.2%	0.1%	* %	50	$.12	$.18	.....
April	261	28,280	5,810	11,060	12.9	9.1	5.2	5.7	110	.21	.39	.050
May	572	114,700	32,140	69,680	28.2	37.0	29.3	35.7	200	.28	.61	.315
June	246	21,120	11,580	16,280	12.2	6.8	10.6	8.4	90	.55	.77	.074
July	250	20,670	11,630	20,450	12.4	6.6	10.6	10.5	80	.56	.99	.093
August	387	39,260	20,410	31,330	19.1	12.6	18.6	16.0	100	.52	.80	.142
Setpember	103	15,430	3,260	5,960	5.0	5.0	2.9	3.0	150	.21	.39	.027
October	157	65,470	23,300	37,820	7.8	21.0	21.3	19.3	420	.36	.58	.171
November	36	5,250	1,500	2,690	1.9	1.7	1.4	1.4	150	.29	.51	.012
FIRE SEASONS.					Relative Risk of Kindling.	Relative Risk of Burning.	Relative Risk of Forest Loss.	Relative Risk of Loss.	Risk of Spreading.	Forest Destructiveness.	Destructiveness.	Risk of Loss.
Spring:												
March 20—June 10	946	155,320	$44,250	$88,370	46.7%	50.1%	40.3%	45.3%	160	.28	.57	.400
Summer:												
June 11—Sept. 20	874	76,040	$39,480	$64,220	43.2%	24.4%	36.0%	32.9%	90	.52	.84	.290
Fall:												
Sept. 21—Nov. 10	202	79,320	$25,960	$42,770	10.1%	25.5%	23.7%	21.8%	390	.33	.54	.194

*Less than .05 of one per cent.

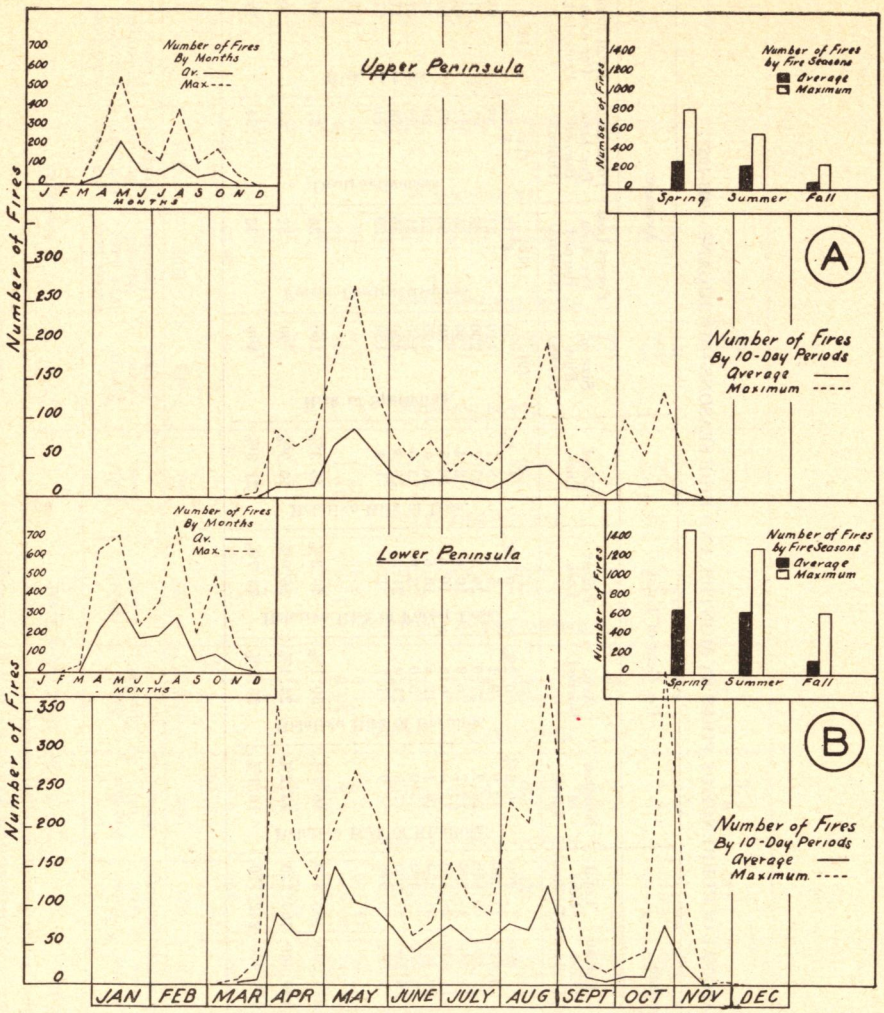


FIGURE 15.—AVERAGE AND MAXIMUM NUMBER OF FIRES REPORTED BY TEN-DAY PERIODS, MONTHS, AND FIRE SEASONS—MICHIGAN. (1920, 1921, 1923-1927 inclusive.) (a) UPPER PENINSULA. (b) LOWER PENINSULA.

The possibility of an early spring outbreak of fires the first ten days in April will also be noted. This indicates the need for the early mobilization of the protective force each year, particularly in the Lower Peninsula where, if the snow goes off early, hazardous conditions are likely to result.

As is to be expected, the length and severity of the fire season differs somewhat from district to district. In general the fire season is longer and more apt to be severe in the more southerly districts. It also increases somewhat in severity from west to east in the Upper Peninsula as shown by Figure 16, which gives the approximate average number of fires by ten-day periods for each protection district. A distinctly higher summer and fall hazard is also to be noted in the Lower Peninsula.

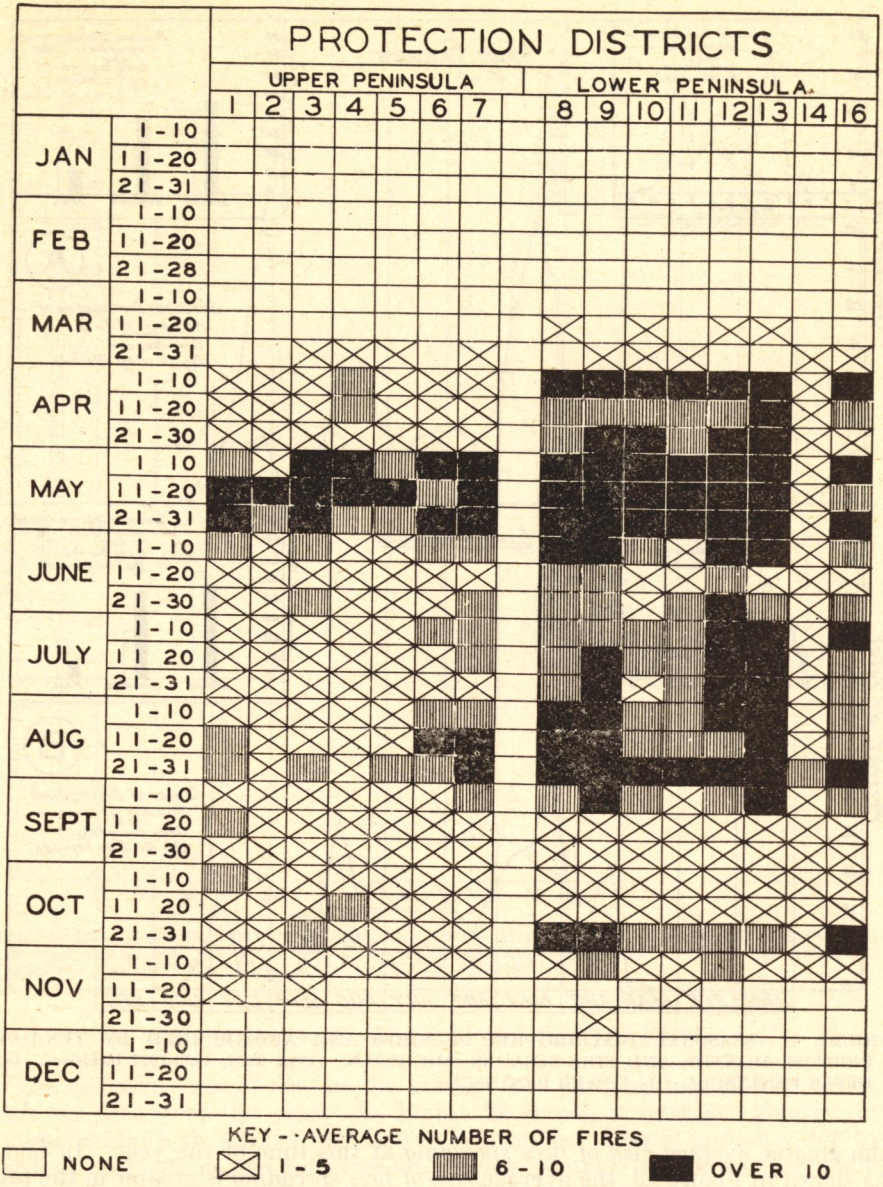


FIGURE 16.—AVERAGE NUMBER OF FIRES BY PROTECTION DISTRICTS AND TEN-DAY PERIODS—MICHIGAN.
(1920, 1921, 1923-1927 inclusive.)

SEASONAL VARIATION IN AREA BURNED

Like *number of fires* the peak months for area burned are May, August, and October. Unlike *number of fires*, however, the average area burned over is greater in October than in August, (see Figure 17). This is explained by

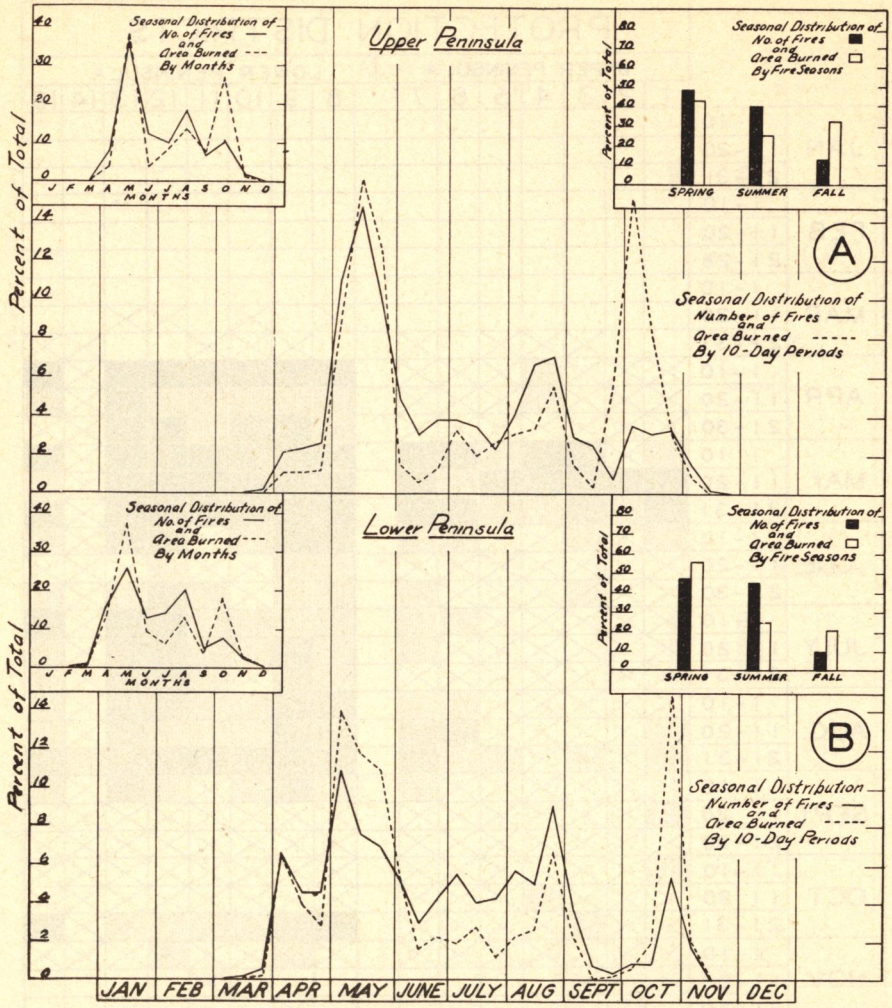


FIGURE 17.—SEASONAL DISTRIBUTION OF FIRES AND AREA BURNED BY TEN-DAY PERIODS, MONTHS, AND FIRE SESAONS—MICHIGAN. (1920, 1921, 1923-1927 inclusive.) (a) UPPER PENINSULA. (b) LOWER PENINSULA.

the greater average *risk of fires spreading* at this time of the year. In fact, as shown in Figure 18, the average *risk of fires spreading* is greater in the fall than at any other season and in October than in any other month, although in the Upper Peninsula, fall fires are confined to exceptional years. This is significant from the standpoint of protection in that it emphasizes the need of intensified fire suppression effort during the fall fire season. This was particularly true in the Upper Peninsula during the period in question as the average area burned over in the fall was considerably greater than in summer, although only about a third as many fires occurred.

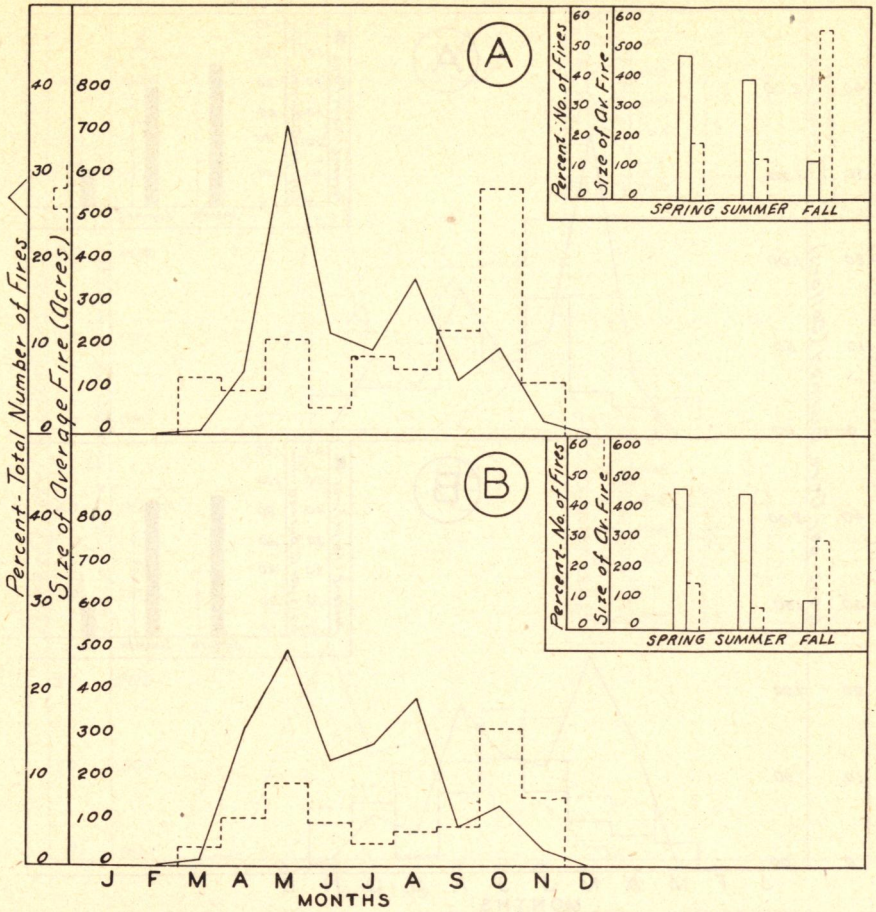


FIGURE 18.—SEASONAL DISTRIBUTION OF FIRES AND SEASONAL RISK OF SPREADING (Average size of fires) BY MONTHS, AND FIRE SEASONS—MICHIGAN. (1920, 1921, 1923-1927 inclusive.) (a) UPPER PENINSULA. (b) LOWER PENINSULA.

SEASONAL DESTRUCTIVENESS OF FIRE

The *destructiveness* of fires or the average loss per acre burned also varies with the season of the year. As Figure 19 shows, it averages greatest in summer in both the Upper and Lower Peninsulas. This is probably due to the fact that spring and fall fires are usually confined to the surface while summer fires are more apt to burn deep. It may also be explained in part by the fact that vegetation is dormant during the greater part of the spring and fall fires seasons and so less susceptible to fire injury.

In the Lower Peninsula, fires are apparently most destructive in July, while in the Upper Peninsula June fires appear to be the most destructive. This may mean that hardwoods, which predominate in the Upper Peninsula, are more susceptible to fire damage during the period of leafing out than at other times, as is often claimed. Further study of fire damage is necessary to settle this point.

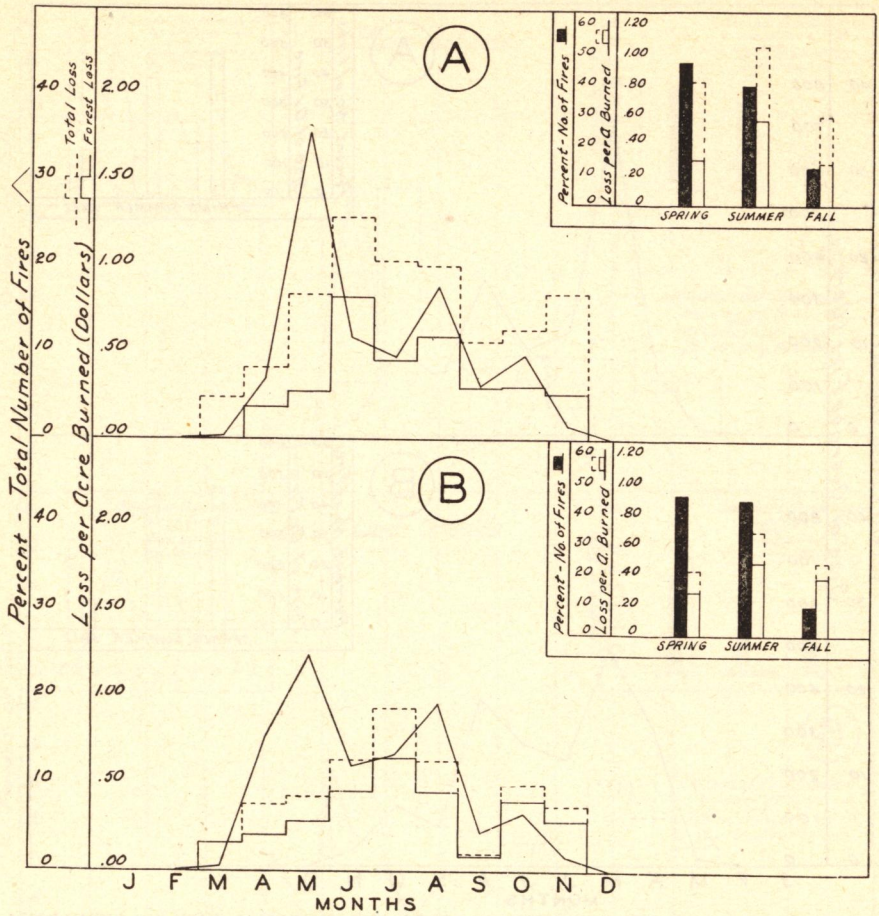


FIGURE 19.—SEASONAL DISTRIBUTION OF FIRES AND SEASONAL DESTRUCTIVENESS (Average loss per acre burned) BY MONTHS, AND FIRE SEASONS—MICHIGAN. (1920, 1921, 1923-1927 inclusive). (a) UPPER PENINSULA. (b) LOWER PENINSULA.

COMBINED SEASONAL RISK

To properly determine the net risk prevailing at different seasons, it is necessary to take number of fires, area burned, and loss per acre, all into consideration since they do not vary uniformly and so tend to augment and offset each other. This may be done by figuring the average current loss per acre protected. Figure 20 shows what this is by months and fire seasons. By fire seasons *risk of loss* or loss per acre protected is greatest in the spring and least in the fall in both Upper and Lower Peninsulas. By months, May is shown to be the month of greatest risk, October and August following in the order named.

All things considered, therefore, spring is the season of greatest risk, summer next, and fall least. While summer exceeds fall as to total risk involved, the fall fire season is apt to be the more acute of the two.

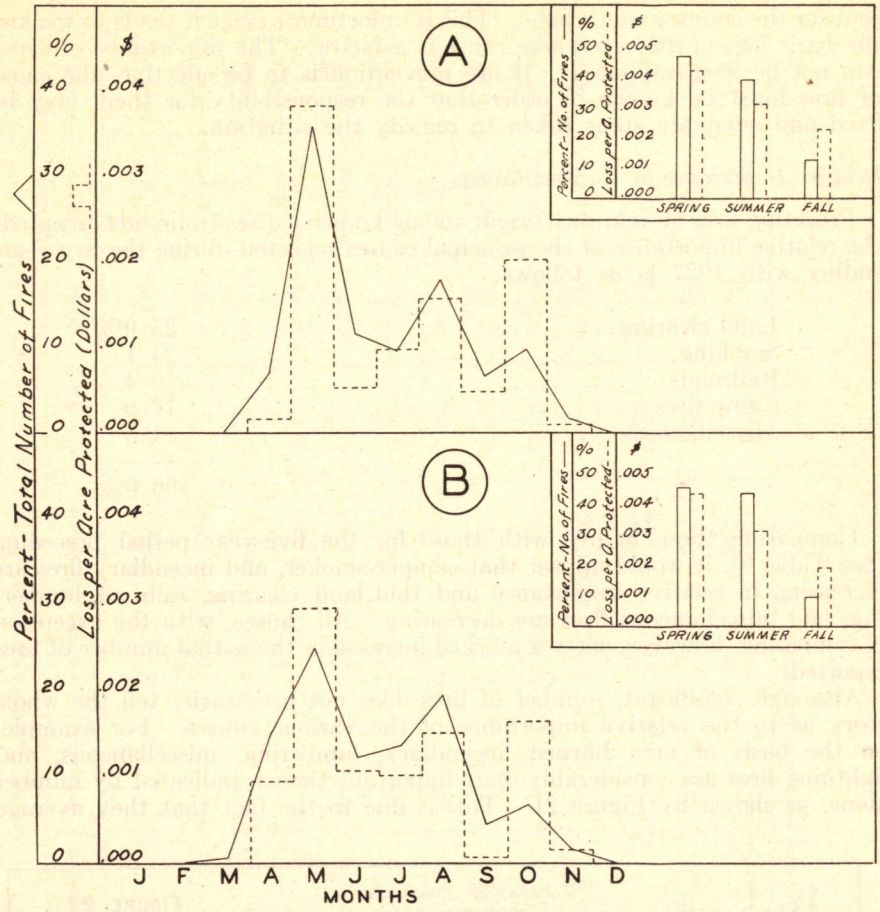


FIGURE 20.—SEASONAL DISTRIBUTION OF FIRES AND SEASONAL RISK OF LOSS (Average loss per acre protected) BY MONTHS AND FIRE SEASONS—MICHIGAN. (1920, 1921, 1923-1927 inclusive.) (a) UPPER PENINSULA. (b) LOWER PENINSULA.

CAUSES OF FOREST FIRES

Principal Causes.

Forest fires in Michigan, as in the Lake States generally, are chiefly due to human carelessness. Less than 1 per cent of the fires of record have been due to lightning and only about 4 per cent have been deliberately set. Settlers, smokers, locomotives, and campers are the chief offenders. The minor causes include incendiarism, lightning, logging, berry pickers, trash burning, meadow burning, sparks from burning buildings, smoking out of bees and animals, bonfires, right-of-way clearing, and children playing with matches. While, in the aggregate, these account for a considerable number of fires, none of them with the possible exception of incendiarism are outstanding although locally one or another may be an important source of trouble.

Each year a large number of fires are reported as of unknown origin. In Michigan over a fourth of the fires are so classified as against about 15 per

cent for the country as a whole. This is unfortunate since it tends to weaken the basis for conclusions where cause is a factor. The importance of cause can not be over-estimated. If fire prevention is to be effective, the cause of fires must be known in order that the responsibility for them may be fixed and adequate steps taken to remedy the situation.

Relative Importance of Various Causes.

Prorating fires of unknown origin among known causes (railroads excepted) the relative importance of the principal causes reported during the five years ending with 1927 is as follows:

Land clearing	25.0%
Smoking	24.1
Railroads	19.4
Camp fires	17.0
Miscellaneous	14.5
	100.0%

Comparing these figures with those for the five-year period preceding (See Table 9), it would appear that camper-smoker, and incendiary fires are increasing in relative importance and that land clearing, railroad, lumbering, and miscellaneous fires are decreasing. All causes, with the exception of lumbering, however, show a marked increase in the actual number of fires reported.

Although significant, number of fires does not necessarily tell the whole story as to the relative importance of the various causes. For example, on the basis of area burned, incendiary, lumbering, miscellaneous, and lightning fires are considerably more important than is indicated by number alone, as shown by Figure 21. This is due to the fact that they average

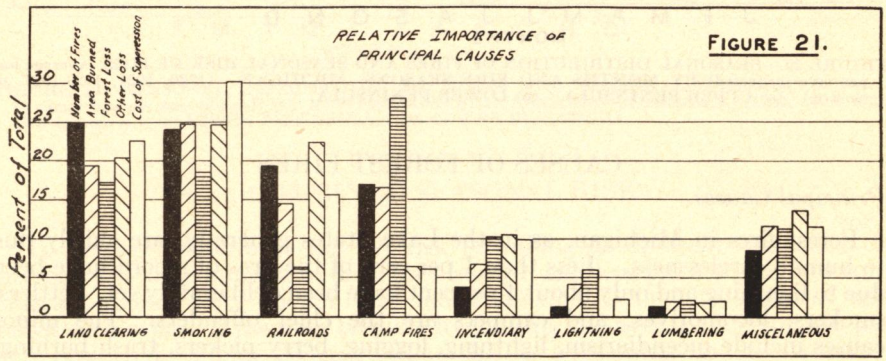


FIGURE 21.—RELATIVE IMPORTANCE OF THE PRINCIPAL CAUSES OF FIRES—MICHIGAN. 1923-1927.

larger. (See Figure 22) Railroad and land clearing fires, on the other hand, average smaller which tends to minimize their importance. Similar differences will be noted, if other bases of comparison are used as shown in Table 10 and Figure 21.

TABLE 9.—NUMBER OF FIRES BY CAUSES AND YEARS—MICHIGAN. 1918-1927

Years.	Land Clearing.	Railroads.	Campfires.	Smokers.	Incendiary.	Lightning.	Lumbering.	Misc.	Unknown.	Total.
1918	131 (18.6%)	165 (23.4%)	85 (12.1%)		31 (4.4%)	21 (3.0%)	17 (2.4%)	55 (7.8%)	199 (28.3%)	704 (100.0%)
1919	159 (18.4%)	234 (27.2%)	66 (7.7%)		10 (1.2%)	2 (0.2%)	0 0	70 (8.1%)	321 (37.2%)	862 (100.0%)
1920	154 (27.5%)	64 (11.4%)	56 (10.0%)		3 (0.5%)	1 (0.2%)	30 (5.4%)	151 (27.0%)	101 (18.0%)	560 (100.0%)
1921	222 (21.6%)	153 (14.9%)	262 (25.5%)		17 (1.7%)	17 (1.7%)	56 (5.4%)	133 (12.9%)	168 (16.3%)	1028 (100.0%)
1922	99 (18.4%)	125 (23.2%)	139 (25.8%)	110 (20.5%)	22 (4.1%)	8 (1.5%)	23 (4.3%)	12 (2.2%)	None Reported	538 (100.0%)
1923	206 (15.4%)	272 (20.4%)	210 (15.7%)	142 (10.6%)	25 (1.9%)	7 (0.5%)	13 (1.0%)	59 (4.4%)	402 (30.1%)	1336 (100.0%)
1924	464 (24.0%)	342 (17.7%)	384 (19.8%)	480 (24.8%)	10 (0.5%)	6 (0.3%)	56 (2.9%)	106 (5.5%)	88 (4.5%)	1936 (100.0%)
1925	629 (16.2%)	703 (18.1%)	446 (11.5%)	437 (11.2%)	121 (3.1%)	39 1.0%)	14 (0.4%)	199 (5.1%)	1299 (33.4%)	3887 (100.0%)
1926	206 (13.5%)	451 (29.6%)	66 (4.3%)	180 (11.8%)	33 (2.2%)	12 (0.8%)	3 (0.2%)	53 (3.5%)	520 (34.1%)	1524 (100.0%)
1927	304 (12.7%)	386 (16.1%)	123 (5.2%)	509 (21.3%)	70 (2.9%)	24 (1.0%)	0 0	202 (8.4%)	776 (32.4%)	2394 (100.0%)
*5-Year Average—1918-22	208.8 (28.3%)	148.2 (20.1%)	196.0 (26.5%)		22.7 (3.1%)	13.4 (1.8%)	34.4 (4.6%)	114.9 (15.6%)	157.8 (21.4%)	738.4 (100.0%)
*5-Year Average—1923-27	553.0 (25.0%)	430.8 (19.4%)	375.7 (17.0%)	534.3 (24.1%)	79.2 (3.6%)	26.9 (1.2%)	26.3 (1.2%)	189.2 (8.5%)	617.0 (27.8%)	2215.4 (100.0%)
*10-Year Average—1918-27	382.0 (25.9%)	289.5 (19.6%)	548.4 (37.1%)		50.8 (3.4%)	20.3 (1.4%)	31.5 (2.1%)	154.4 (10.5%)	387.4 (26.2%)	1476.9 (100.0%)

*Note: "Unknown" fires prorated among known causes, railroads excepted, in figuring averages.

TABLE 10.—RELATIVE IMPORTANCE OF THE PRINCIPAL CAUSES OF FIRE—MICHIGAN. 1923-1927.

Cause.	Per Cent of Total Number of Fires.	Per Cent of Total Area Burned.	Per Cent of Total Forest Loss.	Per Cent of Total Other Loss.	Per Cent of Total Cost of Suppression.
	(1)	(2)	(3)	(4)	(5)
Land Clearing	25.0%	19.5%	17.3%	20.5%	22.6%
Smokers	24.1	24.9	18.7	24.8	30.3
Railroads	19.4	14.5	6.4	22.4	15.6
Camp Fires	17.0	16.6	28.1	6.3	6.0
Incendiary	3.6	6.7	10.2	10.5	9.9
Lightning	1.2	4.2	6.0	.....	2.1
Lumbering	1.2	1.9	2.0	1.8	1.9
Miscellaneous	8.5	11.7	11.3	13.7	11.6
Total	100%	100.0%	100.0%	100.0%	100.0%

Note: "Unknown" fires prorated among known causes, railroad fires excepted.

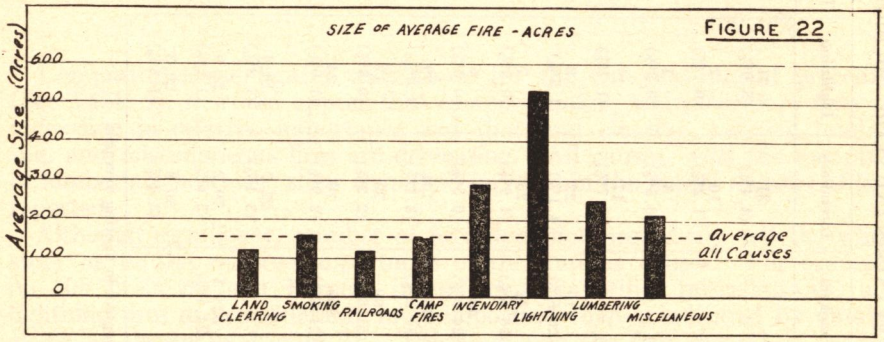


FIGURE 22.—AVERAGE SIZE OF FIRES BY CAUSE—MICHIGAN. 1923-1927.

Distribution and Concentration of Fires by Cause.

Since conditions vary throughout the State, it is to be expected that the relative importance of the various causes will differ from place to place. Table 11, which gives the relative importance of the principal causes for the Upper Peninsula and Lower Peninsula separately shows this to be the case. From the data presented, it will be seen that on the basis of number, land clearing, railroad, and smokers fires, in the order named, lead in importance in the Lower Peninsula, while in the Upper Peninsula smokers fires come first, land clearing second, camp fires third, and railroad fires fourth.

The relative importance of each of the various causes by protection districts, on the basis of number of fires, is given in Table 12. From this table and from Figure 23 it will be seen that land clearing is the chief cause of forest fires in seven districts, smoking in five, camp fires in two, and railroads in one. Smoking, however, is an outstanding cause in practically all districts and railroads in all districts with any considerable railroad mileage.

The concentration of fires by cause, is given in Table 13, by protection districts. For more ready comparison, the same information is presented in Figure 24 for land clearing, railroad, smoking, and camp fires respectively, the districts in which the average number of fires per 100,000 acres exceeds the average for the state being emphasized by shading.

TABLE 11.—RELATIVE IMPORTANCE OF THE PRINCIPAL CAUSES OF FIRE IN THE UPPER AND LOWER PENINSULAS—MICHIGAN. 1923-1927.

UPPER PENINSULA.

Cause.	Per Cent of Total Number Fires.	Per Cent of Area Burned.	Per Cent of Total Timber Damage.	Per Cent of Total Other Damage.	Per Cent of Total Cost of Suppression.
Land Clearing	26.7%	21.3%	23.0%	26.2%	24.6%
Smokers	28.3	32.3	37.8	27.3	29.4
Railroads	13.3	17.4	8.5	19.8	13.5
Campfires	17.1	9.8	15.3	4.0	13.9
Incendiary	4.6	5.2	11.6	16.8	7.7
Lightning	1.9	0.5	*	.....	1.5
Lumbering	0.6	0.4	0.2	0.2	0.2
Miscellaneous	7.5	13.1	3.6	5.7	9.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%

LOWER PENINSULA.

Land Clearing	31.3%	24.5%	19.0%	21.8%	20.6%
Smokers	21.7	17.5	6.8	21.1	23.6
Railroads	22.5	9.0	6.0	13.9	11.0
Campfires	9.8	16.2	24.7	6.9	16.4
Incendiary	3.7	10.6	11.9	1.5	12.5
Lighting	1.4	10.6	13.5	0.2	3.7
Lumbering	0.4	1.3	1.3	2.2	1.3
Miscellaneous	9.2	10.3	16.8	32.4	10.9
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Note: "Unknown" fires prorated among known causes, railroad fires excepted.
*Less than .05 of one per cent.

Obviously, with districts as large as those in Michigan, considerable variation in the concentration of fires locally is to be expected. That this is the case is brought out by Figures 25 to 27 which show the location of land clearing, railroad, and camper-smoker fires reported from 1920 to 1927 inclusive.

In general, lightning fires excepted, accessibility is the chief factor in determining the location and degree of concentration of forest fires, although the hazard prevailing locally is important. For example, in all cases except lightning, fires are more numerous along railroads and highways and in the vicinity of settlements and resorts than in less accessible regions.

In the case of railroad fires, the condition of the right-of-way and the precautions taken to prevent the escape of sparks and live coals from locomotives are the chief factors determining concentration. Modern equipment and properly maintained rights-of-way minimize the danger. As a rule, fires are apt to be more numerous along branch and short line roads. In Michigan, however, some of the larger roads are the worst offenders. In recent years the abandonment of numerous branch and short line railroads in northern Michigan has tended to relieve the railroad fire situation somewhat. More rigid inspection of spark-arresting equipment, ash pans, and rights-of-way has also helped. In spite of inspections, standard equipment, and all ordinary precautions, however, railroads will start fires in dry weather. Constant vigilance, and the wholehearted cooperation of the railroads themselves in detecting and suppressing fires is, therefore, essential if the railroad fire menace is to be dealt with successfully.

TABLE 12.—RELATIVE IMPORTANCE OF PRINCIPAL CAUSES OF FIRE BY PROTECTION DISTRICTS. BASIS: NUMBER OF FIRES—MICHIGAN. 1923-1927.

Districts.	(1) Land Clearing.	(2) Smokers.	(3) Railroads.	(4) Campfires.	(5) Incendiary.	(6) Lightning.	(7) Lumbering.	(8) Misc.	(9) Total.
1	25.8%	12.7%	9.8%	40.5%	0.6%	2.2%	0.6%	7.8%	100%
2	31.9	29.0	11.8	15.1	3.4	4.4	0.5	3.9	100
3	19.3	37.1	14.6	15.9	6.2	1.6	0.6	4.7	100
4	24.0	22.3	14.3	24.3	4.5	.....	.....	10.6	100
5	26.6	39.0	7.3	6.3	7.3	0.5	1.5	11.5	100
6	17.9	41.4	21.9	6.7	2.4	2.7	0.6	6.4	100
7	44.7	15.8	11.8	8.4	8.8	1.0	0.7	18.8	100
8	30.6	23.1	18.2	10.9	4.9	1.6	0.6	10.1	100
9	28.9	18.0	25.2	9.8	4.5	3.3	1.3	9.0	100
10	26.7	37.6	11.7	10.1	3.9	1.5	0.2	8.3	100
11	30.0	32.7	13.8	9.8	4.1	1.7	0.3	7.6	100
12	22.4	15.8	45.1	7.1	1.1	0.5	0.2	7.8	100
13	37.2	13.9	25.0	11.9	2.9	0.5	.....	8.6	100
14	55.8	25.5	3.9	.....	1.3	1.3	.....	12.2	100
16	47.3	11.0	11.1	11.4	4.9	0.3	0.3	13.7	100

Note: "Unknown" fires prorated among known causes, railroad fires excepted.

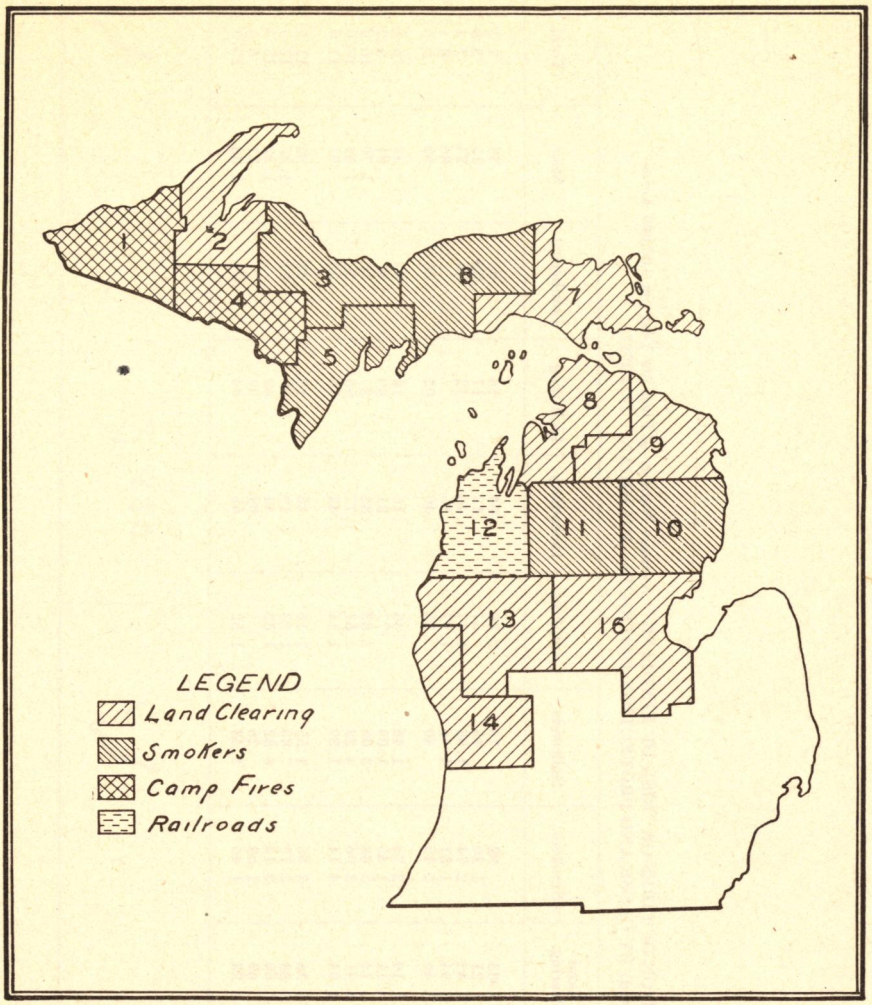


FIGURE 23.—CHIEF CAUSES OF FIRE BY PROTECTION DISTRICTS—MICHIGAN 1923-1927

Seasonal Occurrence of Fires by Cause.

While weather conditions are the major factor in determining the seasonal occurrence of fires, a comparison of the seasonal importance of the various causes brings out the fact that other factors enter into the situation since all causes do not have the same seasonal occurrence. This is brought out by Figure 28 which shows, for each of the principal causes, the per cent of the total number which occur each month and fire season. From this it will be seen that land clearing fires are more numerous in the spring than at any other time of the year in both the Upper and Lower Peninsula. On the other hand, lightning fires are confined almost wholly to the summer months, being practically unknown in the fall and of rare occurrence in the spring.

TABLE 13.—CONCENTRATION OF FIRES OR "RISK OF KINDLING" (Average Number of Fires per Year per 100,000 Acres Protected) BY CAUSE AND PROTECTION DISTRICTS—MICHIGAN. 1923-1927.

Protection District.	Land Clearing.	Smokers.	Railroads.	Campfires.	Incendiary.	Lightning.	Lumbering.	Misc.	Total.
1	1.83	.90	.70	2.88	.04	.16	.04	.55	7.1
2	1.21	1.10	.45	.57	.13	.17	.02	.15	3.8
3	1.42	2.74	1.08	1.17	.46	.12	.05	.34	7.4
4	1.94	1.81	1.16	1.97	.36	.....	.....	.86	8.1
5	1.46	2.15	.40	.35	.40	.03	.08	.63	5.5
6	1.19	2.76	1.46	.45	.16	.18	.04	.43	6.6
7	4.11	1.45	1.09	.77	.81	.09	.07	.81	9.2
8	5.14	3.88	3.06	1.83	.82	.27	.10	1.70	16.8
9	4.91	3.06	4.28	1.67	.77	.56	.22	1.53	17.0
10	2.94	4.14	1.29	1.11	.43	.16	.02	.91	11.0
11	3.36	3.66	1.55	1.10	.46	.19	.03	.85	11.2
12	3.88	2.73	7.80	1.23	.19	.09	.03	1.35	17.3
13	5.69	2.13	3.82	1.82	.44	.08	.....	1.32	15.3
14	3.69	1.69	.26	.....	.09	.09	.....	.81	6.6
16	6.28	1.46	1.48	1.52	.65	.04	.04	1.83	13.3

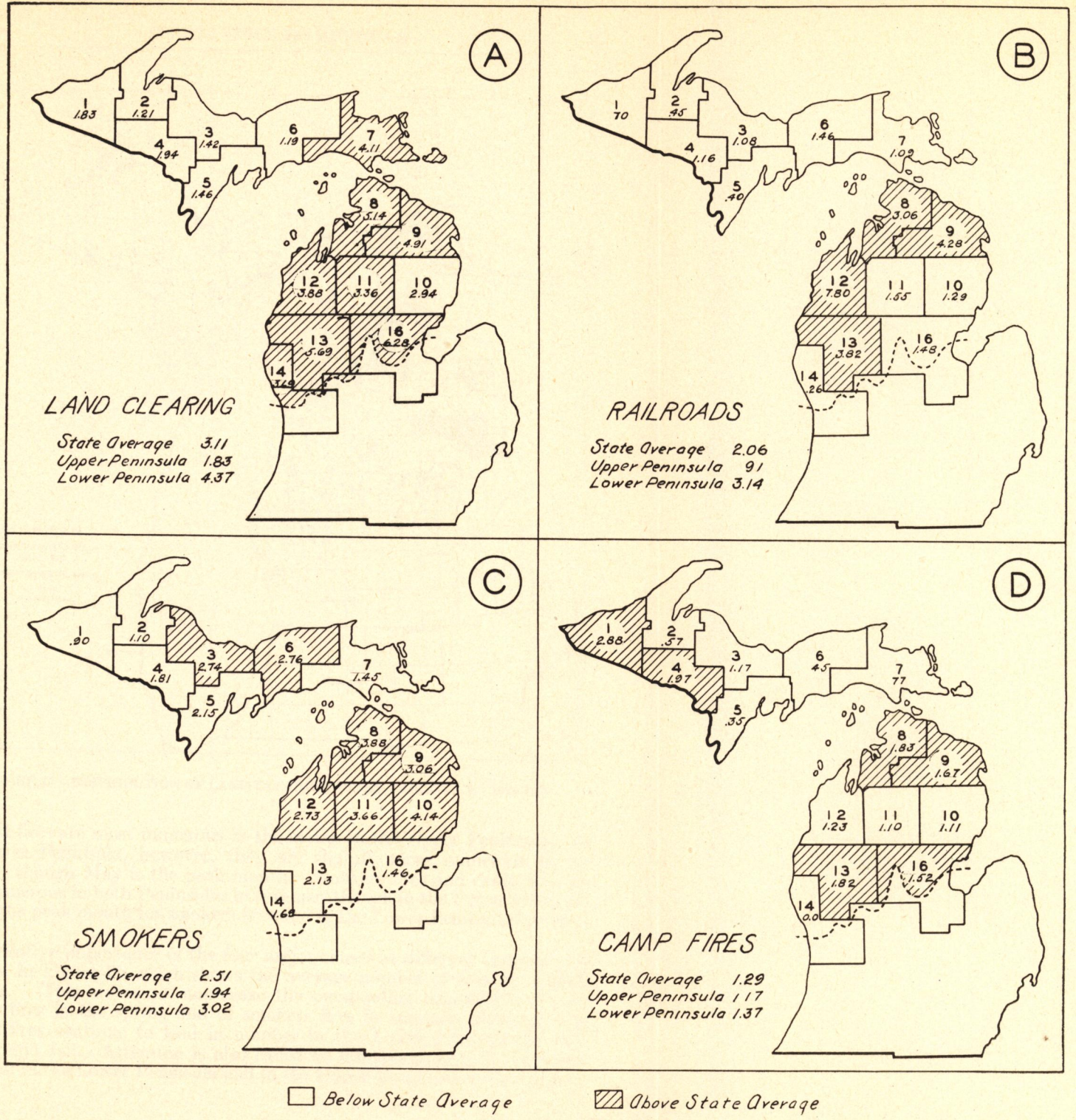


FIGURE 24.—IMPORTANCE OF THE CHIEF CAUSES OF FIRE BY PROTECTION DISTRICTS, BASIS—"RISK OF KINDLING" (Averge Number of Fires per Year per 100,000 Acres Protected)—MICHIGAN. 1923-1927. (a) LAND CLEARING. (b) RAILROADS. (c) SMOKERS. (d) CAMP FIRES.

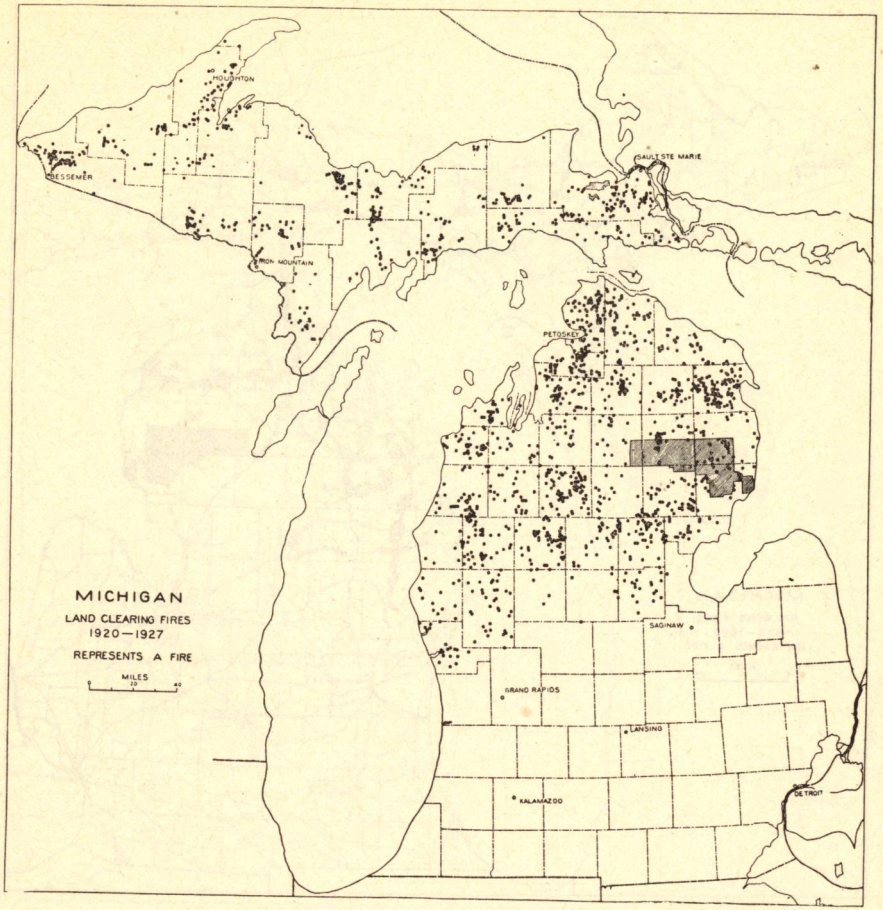


FIGURE 25.—DISTRIBUTION OF LAND CLEARING FIRES—MICHIGAN. 1920-1927.

Railroad fires are most numerous in the spring in the Upper Peninsula. In the Lower Peninsula, however, they are slightly more numerous in the summer, though May is the peak month. Smokers fires and camp fires are more numerous in both Peninsulas in summer, though in the Upper Peninsula May is the peak month for smokers fires and in the Lower Peninsula for camp fires.

The relative importance of the four major causes at different times of year is shown in Figure 29 which shows the average number of fires by months for each. This serves to emphasize the outstanding importance of land clearing fires in the spring and of smokers fires in summer, although land clearing fires continue to lead in number in the Lower Peninsula in both summer and fall. Attention is also called to the importance of camp fires in the fall in the Lower Peninsula and in the Upper Peninsula in the summer.

FIGURE 26.—DISTRIBUTION OF RAILROAD FIRES—MICHIGAN. 1920-1927.

RELATION OF SIZE TO NUMBER OF FIRES, AREA BURNED, DAMAGE AND COST OF SUPPRESSION

Theoretically, damage and cost of suppression are proportional to the size of a fire; damage varying with the area, and cost of suppression with the perimeter. While roughly this is the case, there is a tendency for unit damage to over-run in the case of small fires and to under-run on large fires as is shown by Figure 30 which gives the average damage and cost of suppression per acre for fires of various sizes. This is probably due to the fact that the damage is more closely estimated in the case of small fires which can be gone over in detail and to the fact that the total being small, it is reported in full. Damage estimates in the case of large fires on the other hand, are necessarily more superficial and the total being large, is apt to be minimized. It is a fact, however, that large fires are seldom uniformly destructive which tends to reduce the average damage per acre.

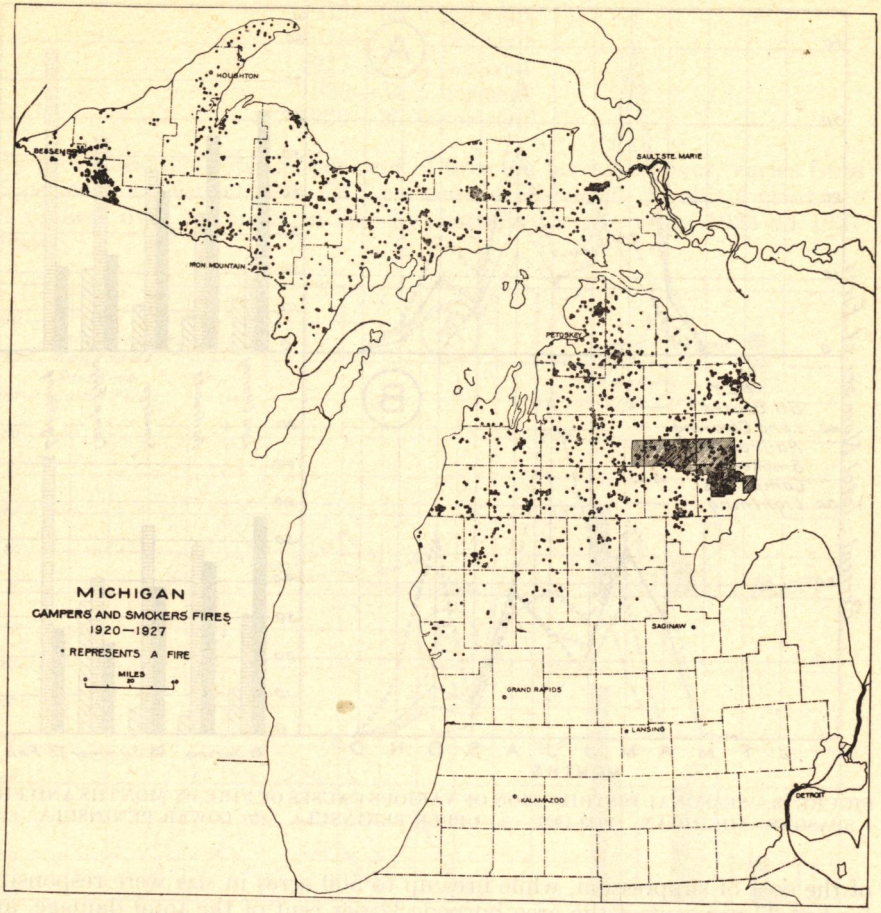


FIGURE 27.—DISTRIBUTION OF CAMPER-SMOKER FIRES—MICHIGAN. 1920-1927.

Unit suppression costs also average high in the case of small fires and low in the case of large fires. This is due to the fact that small fires are usually attacked with a proportionately larger force than large fires, which tends to run up their unit cost. Expenditures on large fires on the other hand, are usually limited by the personnel available which tends to reduce their unit cost both by arbitrarily limiting expenditures and by allowing such fires to become larger than they would if handled by an adequate force.

In spite of the relatively high unit cost and damage of small fires and the low unit cost and damage of large fires, the fact remains that large fires, though comparatively few in number, are responsible for the greater part of the total area burned, damage, and cost of suppression. This is brought out in Figure 31 which shows the per cent of the total number of fires, area burned, damage, and cost of suppression due to fires up to and including various sizes. For example, 80 per cent of the fires, occurring between 1923 and 1927 inclusive, that is to say all fires up to 100 acres in size, were responsible for but 10 per cent of the area burned, 15 per cent of the damage, and 34 per cent

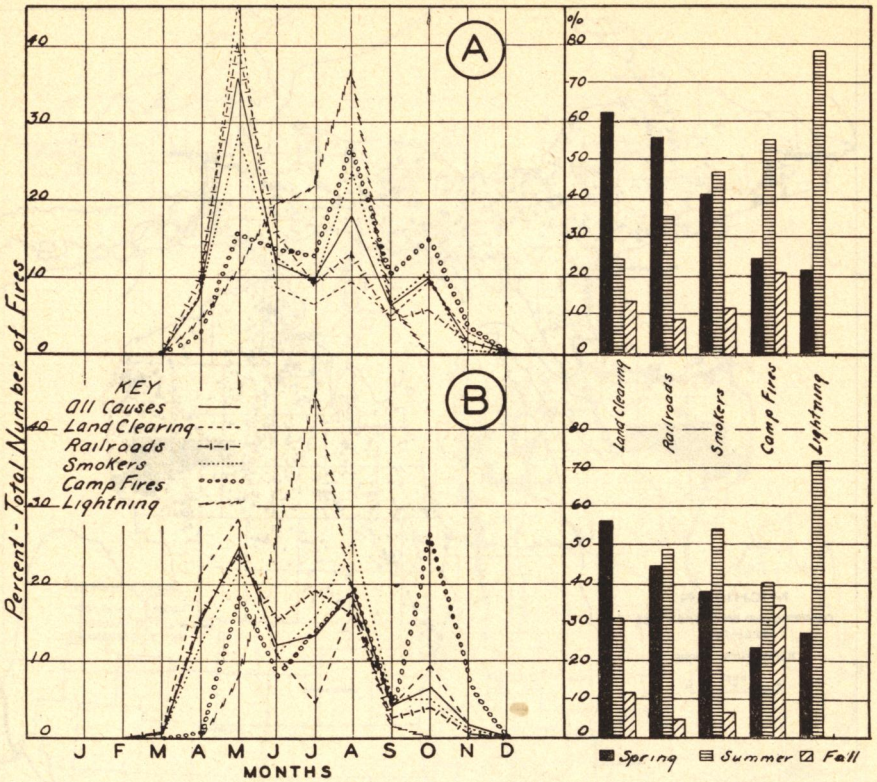


FIGURE 28.—SEASONAL DISTRIBUTION OF VARIOUS CAUSES OF FIRE BY MONTHS AND FIRE SEASONS—MICHIGAN. 1923-1927. (a) UPPER PENINSULA. (b) LOWER PENINSULA.

of the cost of suppression, while fires up to 500 acres in size were responsible for but 27 per cent of the area burned, 32 per cent of the total damage, and 58 per cent of the total cost of suppression, although accounting for 94 per cent of all fires reported. *The importance of keeping fires small, therefore, can not be over-emphasized.*

PER CENT OF FIRES OVER 10 ACRES AS A CRITERION OF THE EFFECTIVENESS OF PROTECTION

The importance of eliminating large fires has led to the use of the per cent of fires over ten acres in size as a criterion of the effectiveness of fire suppression. As shown in Table 5, 58.0 per cent of all fires reported from 1918 to 1927 inclusive, exceeded ten acres in size, although during the last five years of the decade, this percentage was reduced to 52.3 per cent.

That real progress has been made in reducing the per cent of fires over ten acres in size during the last few years is shown by the figures for 1925 to 1929, inclusive, which follow:

1925—62.5 per cent
1926—36.8 per cent
1927—30.4 per cent
1928—34.5 per cent
1929—25.9 per cent

By protection districts the per cent of fires ten acres and over, varies from 33.5 per cent in District 12 to 72.7 per cent in District 4. Table 6 gives per cent of fires over ten acres in size by districts for the years 1923 to 1927 inclusive.

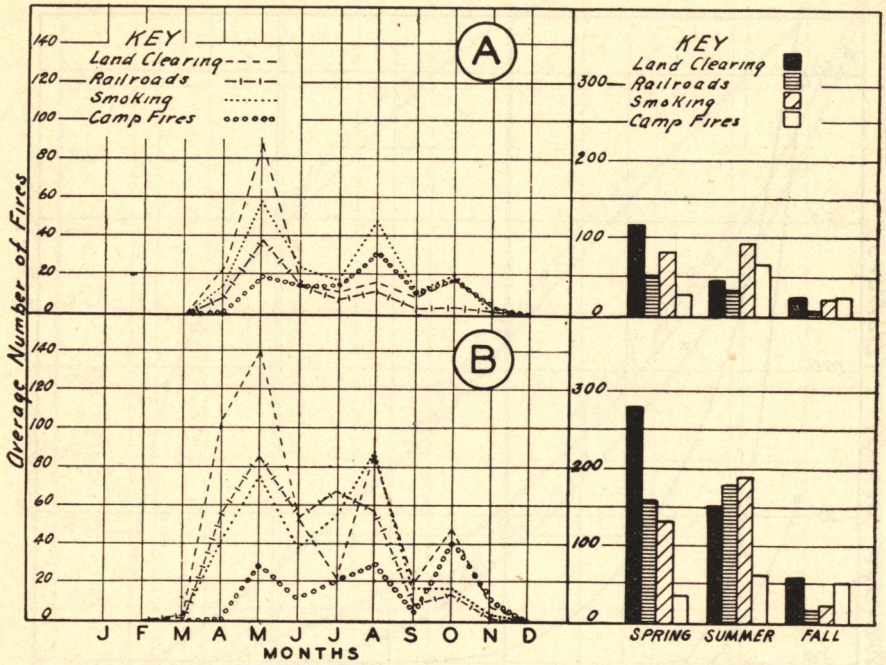


FIGURE 29.—RELATIVE SEASONAL IMPORTANCE OF THE PRINCIPAL CAUSES OF FOREST FIRES BY MONTHS AND FIRE SEASONS—MICHIGAN. 1923-1927. (a) UPPER PENINSULA. (b) LOWER PENINSULA.

Ranking the districts by per cent of fires over ten acres on the basis of the record for the years 1923 to 1927, they fall in the following order, the district with the lowest per cent coming first.

Rank.	District.	Per Cent of Fires over 10 acres.
1	12	33.5%
2	13	35.1
3	1	38.5
4	9	43.7
5	8	44.7
6	6	49.2
7	14	52.1
8	3	53.2

9	11	56.1%
10	10	56.6
11	7	57.0
12	16	62.4
13	5	66.8
14	2	70.0
15	4	72.7

Figure 32 shows the grouping of districts with high and low per cents of fires over ten acres.

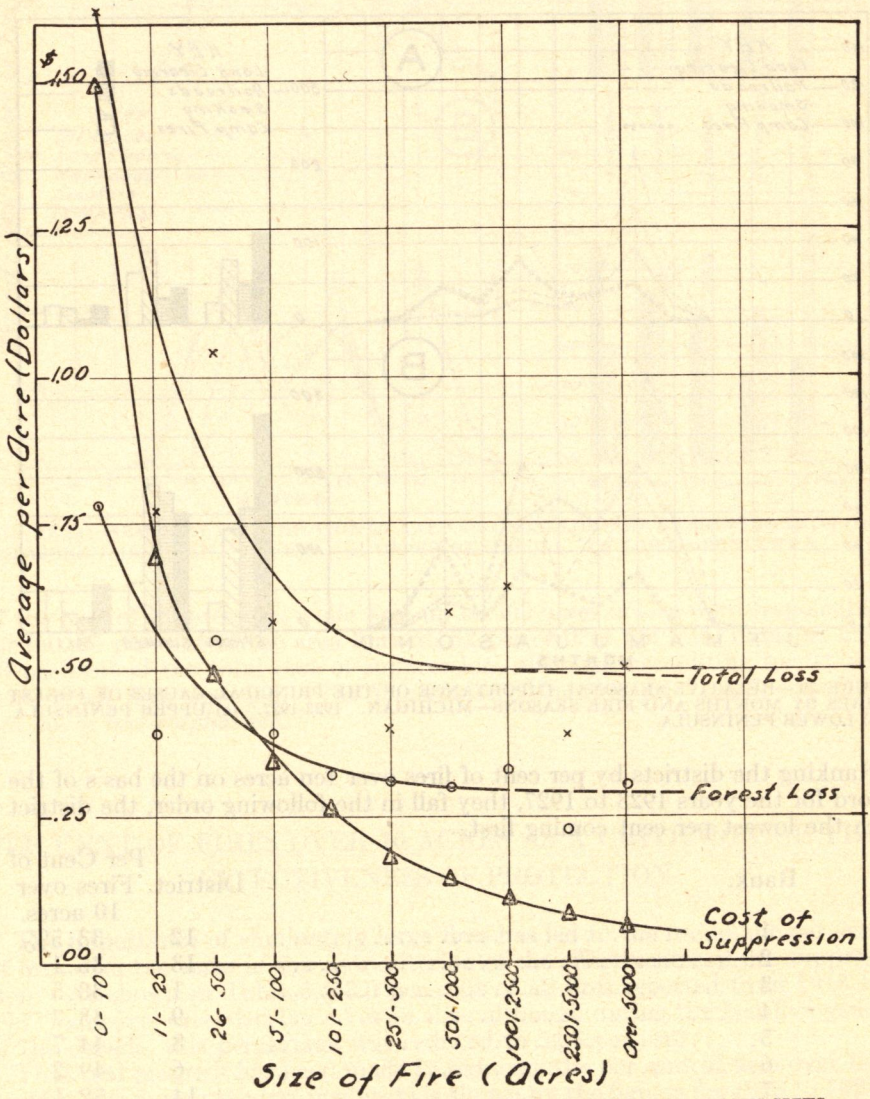


FIGURE 30—AVERAGE LOSS AND COST PER ACRE OF FIRES OF VARIOUS SIZES—MICHIGAN. 1923-1927 DATA.

SUMMARY

Forest fires have been common in Michigan as far back as records are available. Since the beginning of active settlement in 1825 they have been frequent and often disastrous. In the north half of the State they are still a menace to life and property, the arch enemy of wild life and the chief obstacle to reforestation.

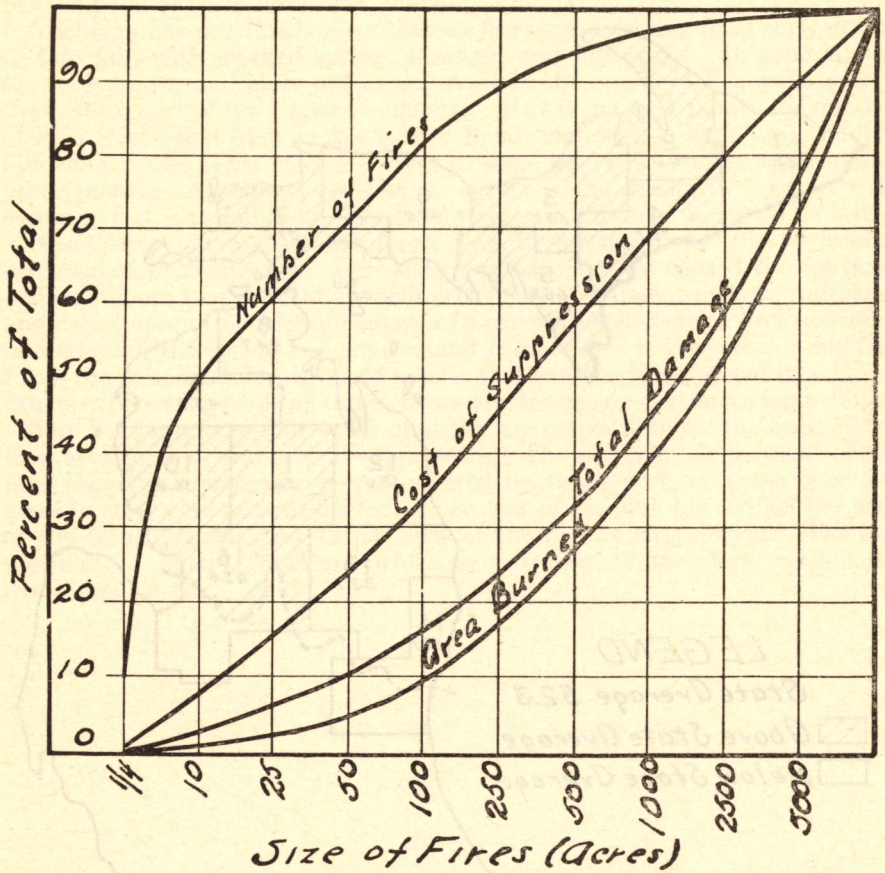


FIGURE 31.—RELATION OF SIZE OF FIRES TO NUMBER, COST OF SUPPRESSING, DAMAGE, AND AREA BURNED—MICHIGAN. 1923-1927 DATA.

Including the farm woods of southern Michigan, the State has in round numbers twenty-two million acres of wild land in need of protection. The bulk of this lies in the Upper and in the north half of the Lower Peninsula. In the Upper Peninsula there is still a considerable area of virgin hardwood and swamp timber. Most of the area in need of protection however, has been cut over and burned repeatedly. As a result, close to ten million acres are now unproductive, while the balance of the cut-over land is largely covered with inferior second-growth.

Second only to the need for putting idle land to work and growing timber

for present and future needs is the desirability of reestablishing a forest cover on cut-over land for the protection of the soil, the regulation of streamflow, the conservation of wild life, and the recreational use of the State's rapidly-growing urban population. The reestablishment of a forest cover will also go a long way toward solving the economic problems of the cut-over land country.

Michigan normally has in the neighborhood of 2,500 fires annually. In bad years there may be twice as many. On the face of the returns, the number

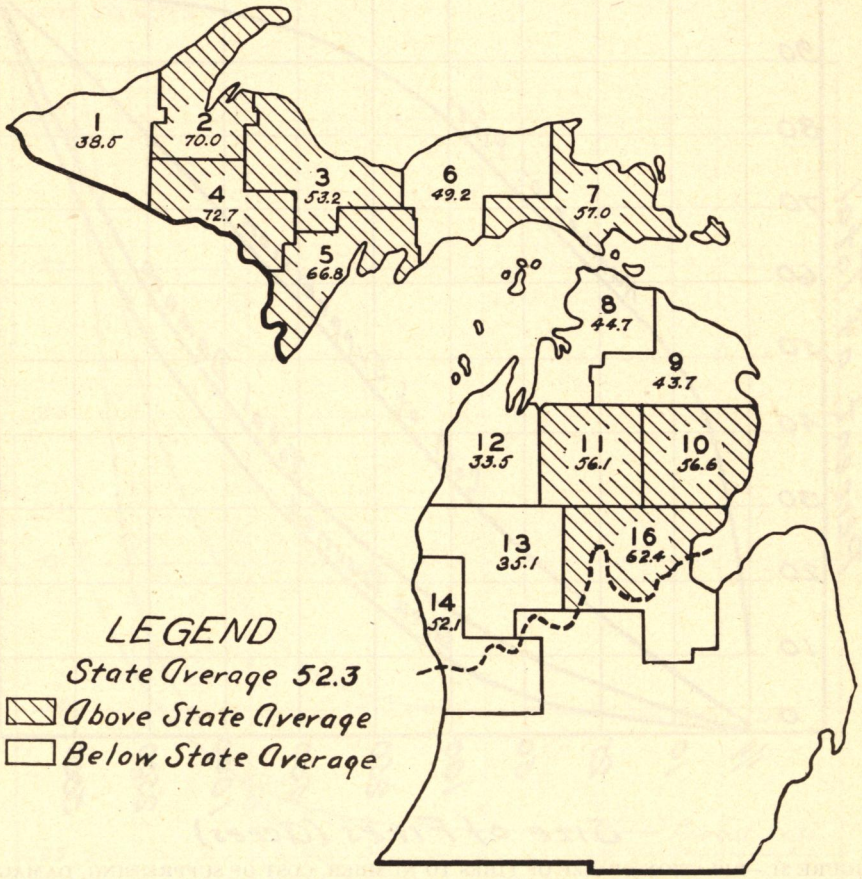


FIGURE 32.—PER CENT OF FIRES OVER TEN ACRES IN SIZE BY PROTECTION DISTRICTS—MICHIGAN. 1923-1927.

of fires is increasing. Better protection, however, has resulted in a material decrease in the area burned and a very marked reduction in the size of the average fire.

While fires occur throughout the area under protection, they are more numerous along railroads and highways and in the vicinity of settlements and resorts, than in less accessible regions. Based on the returns for 1923-1927 inclusive, the *risk of fires starting* is nearly twice as great in the Lower

Peninsula as in the Upper. The *risk of fire spreading* as indicated by the size of the average fire, on the other hand, is greatest in the Upper Peninsula. This indicates a need for better *fire prevention* in the Lower Peninsula and better *fire suppression* in the Upper.

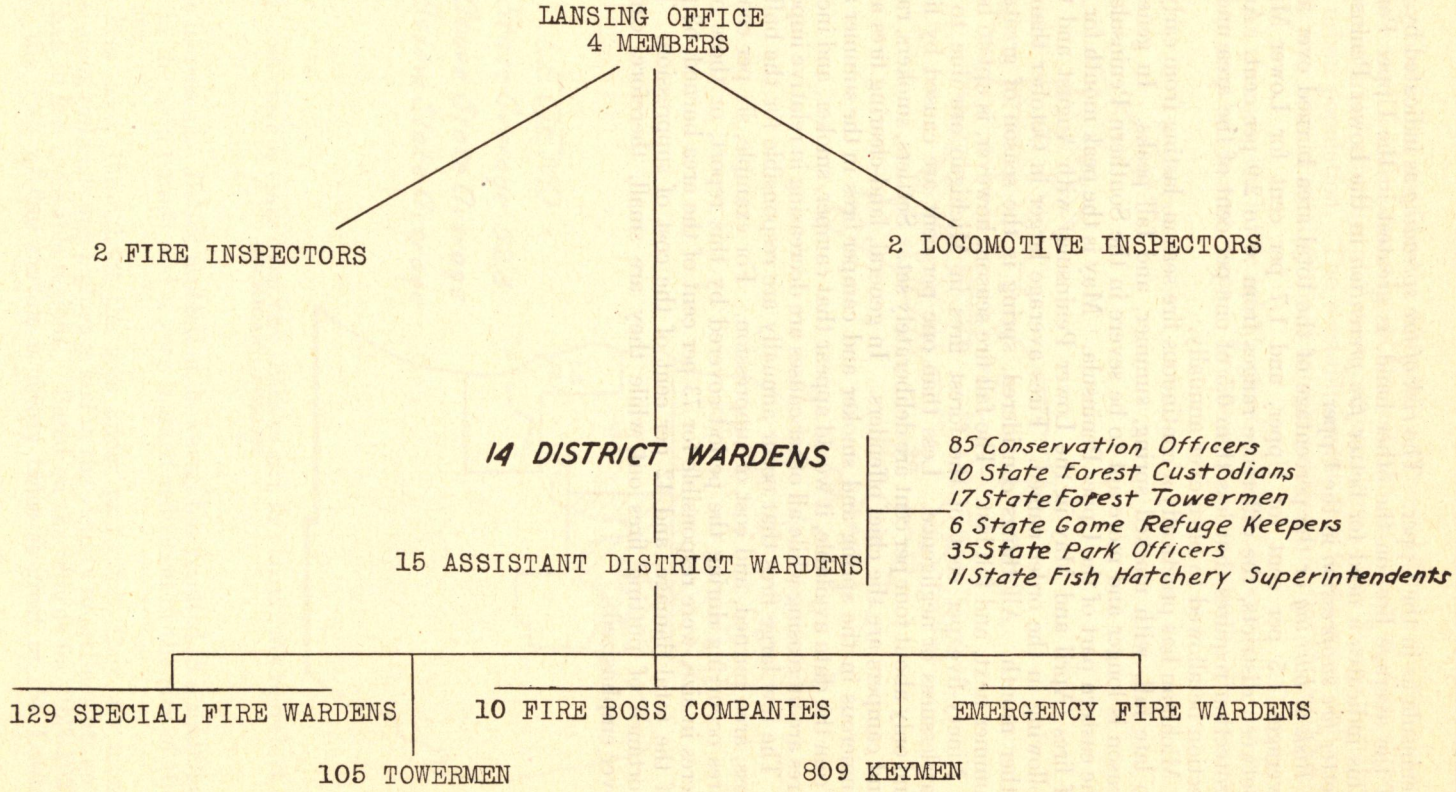
Risk of burning or the percentage of the total area burned over annually averages 1.5 per cent for Upper, and 1.7 per cent for Lower Michigan. Between districts, the difference ranges from .6 to 2.9 per cent. Adequate protection requires that less than 0.5 of one per cent of the area under protection be allowed to burn over annually.

Michigan has practically a continuous fire season, lasting from early spring to late fall, with marked spring, summer, and fall peaks. In general, the season is longer and more apt to be severe in the Southern Peninsula and in the eastern part of the Upper Peninsula. May is the peak month for number of fires (April and May in the Lower Peninsula) with August and October following in the order named. Fires average larger in October than in any other month. All things considered, spring is the season of greatest risk, summer next, and fall last. The fall fire season, however, is apt to be acute.

Ninety-five per cent of the forest fires in Michigan are due to human carelessness or negligence. Less than one per cent are caused by lightning and only about four per cent are deliberately set. Settlers, smokers, railroads, and campers are the chief offenders. In general, land-clearing fires are more numerous in the spring and smoker and camper fires in the summer and fall. From the data available, it would appear that camper, smoker, and incendiary fires are increasing while all other causes are decreasing in relative importance.

The few large fires that occur annually are responsible for the bulk of the loss, area burned, and cost of suppression. For example, six per cent of the fires occurring during the period covered by this report, or those over 500 acres in size, were responsible for 73 per cent of the area burned, 68 per cent of the total damage, and 42 per cent of the cost of suppression. The importance of putting fires out while they are small, therefore, cannot be over emphasized.

FOREST FIRE ORGANIZATION—1929



PART III

PRESENT ORGANIZATION OF THE FOREST FIRE DIVISION

Legislative action in 1921 created the present organization of the Department of Conservation. Formerly, the various divisions now grouped under one department operated individually or under the Public Domain Commission which was abolished in 1921. The divisions making up the present department are: Forest Fire, Lands, Law Enforcement, Forestry, Parks, Fish, Education, Land Economic Survey, Geology, Game and Accounting. The general administration of the Conservation Department is vested in a commission composed of seven members who are appointed by the Governor. The conservation commission appoints the director, who is the active head of the Department. The director appoints with the approval of the commission, the heads of the various divisions of the department.

Since becoming a separate division of the Department of Conservation the Forest Fire organization has developed steadily.

As increased funds became available and as experience was gained in organization needs, changes in the ratios of the different classes of field personnel were made.

Figure 33 shows the organization as of 1929, while Table 14 shows the changes in the classes of field personnel for the period of 1925 to 1929.

Effective July 1, 1923, legislative action required that the entire state be organized into protection districts. Previous to this time there were twelve organized districts in the state, each in charge of a district warden whose duties included all phases of conservation work. After July 1, 1923, the state was reorganized into twenty districts, each in charge of a district warden. Fifteen of these districts, constitute the recognized fire-hazard area of the state.

Up to 1927 all departmental business was handled through a district warden, and the greater part of his time went into the enforcement of game and fish laws and land examination or appraisal, rather than into forest fire control. Up to this time the suppression of actual forest fires constituted the major part of the work carried on by the Fire Division, though a fairly adequate fire tower system was by then in operation.

During 1927 a change was made in the governing personnel of the Division, and although the field organization as already set up was continued, both office and field procedure was reorganized. The prevention side of the forest fire work, which had previously been but little stressed, was developed so as to become an important function of the Division. Division policy, at first rather loosely defined, was made definite through a Manual of Instructions.

The many duties of the district warden gave him very little time for direct participation in forest fire prevention work. This was recognized in 1927 and each district officer was given an assistant, with forest fire prevention and control his sole duty. With the advent of a permanent full-time fireman in each of the fifteen districts, divisional policy and procedure began to shape up and intensify.

As of 1929, the permanent year-long organization of the districts in the fire zone, consists of the district warden and his assistant. The district warden is the Department's representative in the district, theoretically handling all departmental affairs. The time demanded by the Fire Division's work resulted in assigning the work of that Division to the assistant, the

TABLE 14.—CHANGES IN THE CLASSES OF FIELD PERSONNEL. MICHIGAN 1925-1929

Year.	District Wardens.	Assistant District Wardens.	Regular Wardens.	Special Fire Wardens.	Towermen.	Fire Bosses.	Members Fire Boss Companies.	Keymen.
1925	16	0	62	77	92	39	317	689
1926	15	0	75	60	94	30	166	706
1927	15	15	80	80	103	38	246	772
1928	15	15	85	99	104	20	107	805
1929	15	15	85	129	105	10	8	809

district warden functioning only in an advisatory capacity except during periods of extreme hazard when he is actively in charge of suppression work. The assistants for each district represents the year-long personnel of the Forest Fire Division.

The field organization continuously on duty during the six or eight months of the fire season, consists of towermen, special fire wardens, emergency special fire wardens, fire bosses and keymen. Of this list the towermen, special fire wardens and fire bosses, represent the regular salaried members. The towermans sole duty during fire weather is fire detection. Special fire wardens have charge of actual suppression work in their assigned area and they are supported by fire bosses, emergency special fire wardens and keymen. Fire bosses and keymen are assigned a small territory by the special fire warden and handle fires directly under his supervision. Fire bosses are paid a small retainer fee and an hourly rate for the time spent on fire suppression. Keymen do not receive a retainer fee but are paid for actual time spent on fires. In order to increase the size of the full time organization, that is the special fire wardens, during particularly hazardous weather, emergency special fire wardens are employed for continuous duty until the emergency period passes. They function as special fire wardens though under the jurisdiction of the full time special warden of the territory in which they work.

Towermen and special fire wardens are the only members of the organization used on prevention work. Fire lines along railroads, through slash areas and around occasional stands of timber having high value for recreation or game cover; opening up old trails and roads; bridge construction and improvement of tower sites, illustrate the sorts of prevention projects usually worked on. When the weather permits, both towermen and special fire wardens in a district are often bunched on one or two large projects. During 1929, this type of work involved the construction of 14 district headquarters buildings; 78 miles of metallic circuit telephone line; 191 miles of permanent fire line and 74 miles of line rough-broken but requiring further work; erecting 3 closed towers and 2 open towers; moving 2 towers to new sites; 9 plank and pole bridges; 62 miles of roads and trails opened to travel, and various smaller projects such as building 4 cabins in isolated locations, cleaning up slash adjacent to State Parks and improving tower sites.

Since 1923, material changes have been made in the distribution of field personnel. At the beginning of this period 76 special fire wardens were employed, while in 1929 the number had been increased to 129. The value of the special fire warden is more and more evident, and they have increased in proportion to the available appropriation. Towermen have increased as money became available for new towers. At the beginning of the period, 40 towermen were employed, while by 1929 the number of towers regularly manned by the Forest Fire Division had been increased to 105. This number is exclusive of the towers managed by the State Forests and the U. S. Forest Service.

During 1923 the idea of having fire bosses, each with a large company, was stressed, and in 1925 there were 39 such bosses with 317 company members and 689 keymen. The fire bosses received a retainer fee of $25.00 per month and 50c per hour for suppression work, while the members of the companies, though not receiving a retainer fee, were paid at the rate of 40c per hour for fire work, with the impressed labor rate at 20c per hour. Keymen were paid 40c per hour for actual fire work. Later on, the value of fire bosses was questioned and well selected keymen proved to be equal and more effective. In 1929 there were 10 fire bosses with a total of 8 company members

and 809 keymen. In some localities it has been found advantageous to retain the fire boss though in most cases the regular company has been eliminated.

With the advent of additional funds for fire work, through increased state appropriations and federal funds of the Clarke-McNary law, the field and office personnel was increased. As the work of the Division developed changes were made in old procedure and policy and new items of policy and practice were tried.

Increasing the amount of prevention work, made possible by additional funds, made it necessary to change the type of special fire wardens and towermen. The old policy of employing farmers, garage attendants, etc., as special fire wardens who gave their services only in case of fire, has been been changed so that such employees must give their full time to suppression and prevention work.

Fire duties demanded so much of the district warden's time that a point was reached where it was necessary to supply an assistant, whose duty would be fire organization and administration.

It has now been found that detail matters of fire organization and administration take the majority of the time of the assistant district warden and in 1930 another year-long fire-man was assigned to each district. His chief value is in handling district office procedure, to assist in district inspection work and to provide an under-study for the assistant district warden.

The first fire towers erected were of the open type. The tower system now consists of primary towers (closed type), which are manned regularly throughout the season, and secondary towers (open towers), which are manned only during periods of extreme hazard. Secondary towers cover areas of particular value which, according to the Division's visibility maps, are not otherwise well covered during periods of poor visibility, or which warrant additional protection to that offered by the primary towers. All of the open towers originally erected on primary sites have been replaced by closed towers. It is, of course, necessary to have an adequate communication system in connection with detection work and during the past seven years over 400 miles of metallic circuit telephone lines have been constructed.

As field personnel and equipment increased, there was a growing need for centralized district offices, garage and shop facilities. During 1929, 14 such buildings were completed each well located to serve and service the district. These building give ample space for storage of equipment. The sleeping quarters, office room, garage space and workshop supply a long recognized need and greatly increase the efficiency and morale of the field force.

A definite program for the construction of fire lines, the opening up of old roads and trails, making tower sites attractive, and the construction and improvement of tourist camp sites where campfires will be safe, has reduced the time previously lost during wet spells. A working plan to cover such prevention projects is developed by each assistant district warden a year in advance.

New types of forest fire fighting equipment which promise to be of value for suppression work are being tried out. Improvements in old equipment are constantly suggested and tried out. For the past two years, different makes of power pumps, hose and pump equipment, methods of transporting the pumper and equipment, have been in the "try-out" stage. An effort is now being made to find a type of tractor fitted for both suppression and prevention work, and motive equipment which will be efficient in all types of work. A large part of the money available for equipment is to be spent

during the next few years on increasing the number of cars, trucks and tractors of the Division.

In 1929 the United States Forest Service and the Michigan Forest Fire Division in cooperation started a forest fire experiment station. Adequate buildings were constructed and land acquired representative of typical fire conditions. Thus, was established a proving ground for forest fire equipment and experiment station for the study of all phases of fire control and fire damage. Seven definite projects were set up and work was started on these in the spring of 1930. The projects on which work is now being carried on are: fire weather, forest fire fuels, behavior of fires, forest fire damage, use of chemicals in fire control, fire lines and breaks and fire fighting methods and equipment.

FUTURE TRENDS

Little change is anticipated in the size of the organization for some time although considerable effort will be made to increase its effectiveness through increasing its quality. Lessons in fire fighting technique and the use of equipment will be given to the organization at the new experiment station and proving grounds. Instructions in supervision of fires and technique of suppression will be given at district reviews of all fires of consequence.

New methods of suppression, new equipment, use of fire weather reports and behavior of fires are all important projects now being studied at the experiment station. It is expected that the results of further study will have sn important effect on future policies and administration of not only suppresaion work but organization as well.